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APPLIED MECHANICS Reviews

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A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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APPLIED MECHANICS REVIEWS

VOL. 5, NO. 4 MARTIN GOLAND *Editor* APRIL 1952

RECENT CONTRIBUTIONS TO THE THEORY OF SUPERSONIC FLOW

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IN THIS article, an attempt will be made to give a systematic survey on the development of the mathematical theory of nonviscous supersonic flow since 1945. We shall deal not only with steady flow but also with the unsteady flow arising from oscillating obstacles in a uniform supersonic stream. Furthermore, the present paper includes the two limiting cases of supersonic flow: the transonic flow occurring in mixed flow patterns, and the hypersonic flow. However, according to the restriction to nonviscous flow, the boundary-layer problems are not reviewed in this article.

TEXTBOOKS

Recent textbooks on the mathematical theory of supersonic flow are: [1] R. Courant and K. O. Friedrichs (1948, AMR **1**, Rev. 1661); [2] H. W. Liepmann and A. E. Puckett (1948, AMR **2**, Rev. 219); [3] A. Ferri (1949, AMR **2**, Rev. 1291); [4], [5] R. Sauer (1951, AMR **4**, Revs. 3930, 4217). Furthermore, the classic paper: [6] Th. von Kármán, "Supersonic aerodynamics, principles and applications" (AMR **1**, Rev. 133) is to be mentioned. In the following, reference to these publications will be made by giving the number of the present list in brackets and adding the page number.

LINEAR THEORY OF STEADY SUPERSONIC FLOW

The linear theory was initiated in 1925 by J. Ackeret for two-dimensional flow and, some years later, by Th. von Kármán, N. B. Moore, and H. S. Tsien and, independently, by C. Ferrari for slender bodies of revolution with vanishing or small angle of attack. In the past decade, further linear theories were developed for properly three-dimensional flow problems (flat wings with finite span, body-wing combinations); hereby, the fundamental concepts of supersonic and subsonic leading or trailing edges were introduced. Three methods were built up:

(*a*) The method of singularities used formerly for bodies of revolution (one-dimensional distributions of sources and sinks, doublets and vortexes) was extended to flat wings of finite span (analogous two-dimensional distributions); see [6], p. 377, A. E. Puckett and H. J. Stewart (AMR **1**, Rev. 151), E. Pistolesi (AMR **4**, Rev. 3632), and I. C. Evvard (AMR **1**, Revs. 688, 689, 1016). The classic method of Hadamard, wherein he introduces the "finite parts" of diverging integrals, gives a natural unification of the various solutions in three-dimensional supersonic-wing theory; see M. A. Heaslet and H. Lomax (AMR **1**, Rev. 500; **3**, Rev. 310), A. Robinson (AMR **2**, Revs. 1293, 1418, 1419), and E. V. Laitone (AMR **3**, Rev. 2708). But reviewer believes that the new more general concept of "distributions" (L. Schwartz: "Théorie des distributions I, II," Paris, 1950, 1951) will be the most powerful mathematical tool for future research in this field.

(*b*) The "acoustic analogy" introduced by von Kármán is another extremely useful method. The calculations are greatly simplified by the application of Fourier integrals (AMR **1**, Rev. 133); see also [6], p. 378, and C. C. Chang (AMR **4**, Rev. 4219).

(*c*) The elegant method of conical flow introduced in 1943 by A. Busemann (AMR **1**, Rev. 684, and [5], p. 157) reduces the three-dimensional hyperbolic problem to a two-dimensional one of elliptic type and allows the use of conformal mapping. Several authors applied this method for drag and lift computation of delta wings, rectangular wings, arrow-shaped wings, and other ones; see H. J. Stewart (*Quart. appl. Math.* **4**, no. 3, 1946), R. M. Snow (AMR **1**, Rev. 536), M. J. Gurevich (AMR **4**, Rev. 313), P. Germain (AMR **3**, Rev. 2402; **4**, Rev. 2152). A generalization of Busemann's conical flow is Germain's homogeneous flow (AMR **3**, Rev. 103). H. Behrbohm and K. Oswatitsch studied flat conical bodies in supersonic flow by reducing the problem to a singular integral equation of the Prandtl "lifting-line" type (AMR **4**, Rev. 4516). The general drag and lift problem of finite span wings based on linear theory is discussed in detail by von Kármán [6], p. 378 ff. The pressure on slender bodies that does not have rotational symmetry was calculated by E. W. Graham (AMR **4**, Rev. 4513). The wing-body interference problem was treated by C. Ferrari (AMR **1**, Rev. 1268), S. H. Browne, L. Friedman, and J. Hodes (AMR **1**, Rev. 1240), R. M. Stocker (AMR **4**, Rev. 4236), P. A. Lagerstrom and M. E. Graham (AMR **4**, Rev. 3000), G. Morikawa (AMR **4**, Rev. 4512), and others. C. Ferrari (AMR **3**, Rev. 2414) attacked the interference problem also in the range of the exact, nonlinear theory of supersonic flow by using the method of characteristics.

LINEAR THEORY OF OSCILLATING BODIES IN SUPERSONIC FLOW

The basic work of C. Possio (1937), S. von Borbély (*ZAMM* **22**, p. 190, 1942), and L. Schwarz (1943; see AMR **4**, Rev. 809) was continued by I. C. Evvard (AMR **1**, Rev. 1512), I. E. Garrick and S. J. Rubinow (AMR **1**, Rev. 719; **3**, Revs. 123, 757),

W. Strang (AMR **2**, Rev. 333; **4**, Rev. 2118), C. Gardner (AMR **4**, Revs. 2124, 2125), C. C. Chang (AMR **2**, Rev. 221; **4**, Rev. 4514), and particularly by J. W. Miles (AMR **1**, Rev. 156; **3**, Rev. 2400; **4**, Revs. 329, 330, 332, 333, 790, 2119, 2120, 2126, 2128, 2143). These investigations concern both periodic and transient motions and two-dimensional as well as three-dimensional problems. K. Stewartson applied Laplace transformations to several problems of unsteady supersonic flow (AMR **4**, Revs. 1238, 2121). P. Germain and R. Bader (AMR **2**, Rev. 1160) studied harmonic oscillations by means of a correspondence with homogeneous flow.

In the case of slow periodical oscillations, it is possible to reduce the time-dependent flow problem to a simple time-free, steady-flow problem by neglecting powers of frequency higher than the first. The most general use of this reduction was made by J. W. Miles (AMR **4**, Rev. 333). The same method was used by R. Sauer in order to compute the pitching force and damping moment of pendulating projectiles (Int. Congr. of Math., Cambridge, Mass., 1950).

SHOCK CONFIGURATIONS

Before we deal with the exact, nonlinear supersonic-flow theory, a few remarks on shock configurations may be inserted. The algebraic problem of three-shocks configurations (λ-shock) is investigated by Courant [1], p. 332. Independently, it had been attacked by H. Eggingk (AMR **1**, Rev. 496) and by A. Weise in 1943. Recently, some further studies were made by F. Wecken (AMR **3**, Rev. 304) who discussed the criteria of Cranz-Schardin and Schultz-Grunow, and by W. Wuest (AMR **3**, Rev. 754); see also W. Kofink (*Annalen der Physik* **9**, pp. 200, 401, 1951). H. Polachek and R. J. Seeger (AMR **3**, Rev. 1530) presented a detailed summary of the algebraic theory of shock interactions and studied shock-wave phenomena in waterlike substances (AMR **4**, Revs. 2107, 4519). H. Richter (AMR **3**, Rev. 303) studied the stability problem of a shock in a concave corner; he explained the stability of the weak solution and the instability of the strong one by means of the shock-polar diagram.

EXACT THEORY OF SUPERSONIC FLOW

The fundamental mathematical tool in this field is the theory of characteristics of hyperbolic quasilinear partial differential equations. The first use of this theory was made by Prandtl and Busemann (1929) in order to construct two-dimensional supersonic potential flows. Some years later, many mathematicians—Ferrari (AMR **1**, Rev. 1242), Guderley, Sauer, Tollmien, and others—developed numerical and graphical finite-difference procedures in characteristic networks for axially symmetric three-dimensional flow and for rotational flow; see [4] p. 118, and [5] p. 144. The basic mathematical theory is summarized in the book of Courant and Friedrichs [1], p. 37, and was completed in a later paper of R. Courant and P. Lax (*Comm. pure and appl. Math.* **2**, p. 255, 1949) where existence theorems for initial value problems are proved. Further studies on the convergence of the finite-difference procedures used in supersonic-flow theory and error evaluations will be an important topic for future research; a beginning of error evaluations was made by M. Holt (AMR **3**, Rev. 1995) and P. Teofilato (AMR **4**, Rev. 4531).

Asymmetric three-dimensional supersonic-flow problems were attacked along two lines: (*a*) Finite-difference procedures in a spatial network based upon the three-dimensional theory of characteristics were attempted first by C. Ferrari (*Atti R. Accad. Sci., Torino* **72**, p. 140, 1936) and later by A. Ferri (see [3], p. 282, and AMR **3**, Rev. 1321), N. Coburn and C. L. Dolph (AMR **3**, Rev. 1523), and others; see also R. Sauer (*ZAMM* **30**, p. 347, 1950). (*b*) A half-linear method starting from exact three-dimensional solutions with axial symmetry and superposing linear perturbations was built up by R. Sauer (1942; see [5], p. 166; see also P. Carrière (AMR **3**, Rev. 1327). Applications were made to bodies of revolution with small angle of attack and, especially, to the investigation of the neighborhood of the vertex of pointed bodies of revolution (curvatures of shock wave shape and body shape, pressure gradient). The latter problem and the analogous one in two-dimensional flow were treated also by M. M. Munk and R. C. Prim (AMR **1**, Rev. 1665), and by H. Cabannes (AMR **4**, Rev. 2583).

The special case of supersonic flow past yawing cones with attached shock wave was treated by R. Sauer in 1942 with neglection of vorticity. Improved theories with full consideration of vorticity were given by A. H. Stone (AMR **1**, Rev. 993, and *Nat. defense Res. Counc. Rep.* no. A 358, 1945) and, independently, by R. Sauer [5], p. 167; see also M. Lotkin (AMR **1**, Rev. 1664; **3**, Rev. 528), A. Ferri (AMR **3**, Rev. 1321; **4**, Rev. 1650), and C. Ferrari (AMR **4**, Rev. 3312). Zd. Kopal presented extensive tables for practical use (*MIT, Tech. Rep.* no. 3, 1947, and no. 5, 1949; see AMR **3**, Rev. 935).

In the range of the exact supersonic-flow theory there are to be mentioned also the investigations concerning the limiting line by K. O. Friedrichs (AMR **3**, Rev. 753), W. Tollmien (AMR **3**, Rev. 1128), and M. Schaefer (AMR **3**, Rev. 526).

HYPERSONIC FLOW

The limiting case of supersonic flow for infinitely increasing Mach numbers in the range where it is allowed to consider the gas as a continuous medium is usually called hypersonic flow. Limiting solutions of the supersonic-flow equations for increasing Mach numbers were discussed by S. Falkovich (AMR **1**, Rev. 1247; **3**, Rev. 2705) who introduced a hypothetical pressure-density law and transformed in this way the potential equation into a Darboux equation. However, the most important progress in hypersonic-flow theory is based on H. S. Tsien's similarity laws (*J. Math. Phys.* **25**, p. 247, 1946); see also W. D. Hayes (*Quart. appl. Math.* **5**, p. 105, 1947). Applications of these laws were made by S. F. Shen (AMR **1**, Rev. 1511) to slender cones and by R. D. Linnell (AMR **2**, Rev. 353) to infinite wings. Recently, K. Oswatitsch (AMR **5**, Rev. 190) established similarity laws by using a different approach where the shock-wave equations are involved.

TRANSONIC FLOW

The other limiting case of supersonic flow is the transonic flow with Mach numbers near to 1.0. The usual linear theory of supersonic flow has to be replaced by nonlinear approximations leading to a Tricomi equation (AMR **3**, Rev. 114) for velocity potential. On the basis of this equation, von Kármán (AMR **1**, Rev. 508; see also [6], p. 396, and C. Kaplan, AMR **1**, Rev. 997) and, independently, G. Guderley developed transonic similarity laws equally important for theory and practice. Applications were made particularly by H. S. Tsien and J. R. Baron (AMR **2**, Rev. 509). J. R. Spreiter (AMR **4**, Rev. 1665) built up analogous similarity laws for wings of finite span. A different approach was attempted by K. Oswatitsch (AMR **3**, Rev. 1525; *Roy. Inst. of Technology, Stockholm, Tech. Notes* no. 1920, 1947, and nos. 14, 15, 1950.

Transonic flow occurs in mixed flow patterns such as (*a*) in flow at high subsonic speed past obstacles with a local supersonic domain, and (*b*) in supersonic flow past obstacles with detached shock wave and, therefore, containing a local subsonic domain.

(*a*) The structure of subsonic flows with supersonic domain was discussed by G. Guderley (AMR **2**, Revs. 1296, 1426). An enlightening investigation on the drag problem at high subsonic speeds avoiding any mathematical apparatus was presented by A. Busemann (AMR **3**, Rev. 1742). K. Oswatitsch

(AMR 4, Rev. 302) studied the velocity distribution at local supersonic ranges by solving approximately a nonlinear integral equation. Flows around obstacles and jets with free-stream Mach number 1.0. were treated by G. Guderley and H. Yoshihara (AMR 2, Rev. 1297; 3, Rev. 2723; 4, Revs. 1664, 3299). The question of appearance of a shock wave in the supersonic range of a mixed flow is closely connected with the problem of interaction between boundary layer and shock waves; see von Kármán [6], p. 395. The analytical possibility of existence of shock-free mixed flows around profiles is not yet rigorously cleared.

(*b*) Supersonic flows with a subsonic domain downstream of a detached shock wave offer nearly the same mathematical difficulties as the mixed flow patterns of the type (*a*) because in both cases, the basic differential equations are hyperbolic in the supersonic range and elliptic in the subsonic range. After first attempts undertaken by J. C. Maccoll, several authors used half-experimental methods. They started from a given shape of the shock wave and added certain assumptions concerning the sonic line, whereafter they applied a numerical finite-difference procedure; see G. Drougge (AMR 3, Rev. 314), H. Cabannes (AMR 3, Rev. 2407; 4, Rev. 4220). H. W. Liepmann and A. E. Bryson, Jr. (AMR 4, Rev. 3298) compared some experimental results and the theoretical work of von Kármán, G. Guderley, and J. D. Cole (AMR 4, Rev. 4527). Useful interferograms of flows past cones and spheres with detached shock wave were given by J. W. Heberle and G. P. Wood (AMR 3, Rev. 1986). Of particular interest is A. Busemann's article (AMR 3, Rev. 2001) where he reviews the analytical methods, placing emphasis on supersonic-speed range close to Mach number 1.0.; he points out the important result that the connection between body shape and shock-wave shape is by no means a simple analytical one and, therefore, cannot be represented by a few terms of a power-series development. See also W. G. Vincenti and C. B. Wagoner (AMR 4, Rev. 4530) who recently treated transonic flow past a wedge profile with detached shock wave.

M. J. Lighthill (AMR 1, Rev. 994) and, recently, S. Tomotika and K. Tamada (AMR 3, Rev. 1982; 4, Revs. 2113, 3936) studied two-dimensional transonic flow by solving simplified equations in the hodograph plane. Finally, S. Bergman's method of integral operators (AMR 3, Rev. 751) may be mentioned which is extremely useful, not only for purely subsonic two-dimensional flow problems but also, if applied to Tricomi's equation, for the study of transonic two-dimensional flow patterns (AMR 1, Rev. 336); see also R. von Mises (AMR 1, Rev. 1506).

Communications

Concerning AMR 4, Rev. 4013 (Oct. 1951): M. J. Hvorslev, Time lag and soil permeability in ground-water observations.

The review is misleading since it deals only with a secondary problem, discussed briefly in the last section of the paper. The principal subject of the paper is not "on-the-site permeability measurements," as claimed by the reviewer, but determination of ground-water levels and pressures by means of borings, piezometers, and pressure cells. Common sources of error in such measurements are discussed in summary form. The most conspicuous of these sources of error is the time lag, and theoretical and experimental methods for determination of its magnitude and its influence on the results of field observations are developed for both stationary, uniformly changing, and fluctuating ground-water conditions. Application of the proposed methods is facilitated by tables and examples, by a summary of commonly used formulas for flow of water through various types of intakes or well points, and by expanding these formulas to include the influence of anisotropic permeability of the soil.

Borings and piezometers are often used as variable head permeameters for approximate determination of the permeability of the soil in situ. After a limited distribution of a first draft of the paper, the writer received inquiries concerning the use of the aforementioned formulas and methods for permeability determinations, and the problem is discussed briefly in the final draft of the paper. The potential advantages of the method are recognized, and it is demonstrated that some sources of error can be detected or eliminated by the plotting of time lag diagrams. However, it is also emphasized, both in the preface and in the closing paragraphs of the paper, that many other sources of error may be active, and that the results cannot be considered fully reliable before means for eliminating these sources of error or estimating their influence on the observations have been developed.

M. J. Hvorslev, USA

Concerning AMR 5, Rev. 53 (January 1952): A. J. Durelli and R. L. Lake, Some unorthodox procedures in photoelasticity.

The reviewer notes that when the "creeping" method is used it is not necessary that the models have regions of known stress or calibration parts built into them to determine the stress distribution. The calibrating specimen may be separated from the model. The only requirement is that the elapsed time between application of the loads and determination of fringe values be identical for model and calibration specimen.

M. M. Leven, USA

Theoretical and Experimental Methods

(See also Revs. 1010, 1124, 1128, 1136, 1149, 1168, 1201, 1226, 1236, 1253)

949. Kottler, F., The goodness of fit and the distribution of particle sizes. I, II. *J. Franklin Inst.* **251,** 5, 6; 499–514, 617–641; June 1951.

Paper deals with the fitting of a normal frequency distribution on grouped data by minimum chi-square method. Treatment of right tail of the curve is erroneous. The statistical remarks of the author are, as a whole, seriously misleading; especially, use of chi-square test of goodness of fit as advocated on p. 511 is definitely incorrect. Section on heterogeneity (p. 627) could be of interest if more clearly written.

Lucien Le Cam, USA

950. Flomenhoft, H. I., A method for determining mode shapes and frequencies above the fundamental by matrix iteration, *J. appl. Mech.* **17,** 3, 249–256, Sept. 1950.

The particular advantage of the matrix-iteration method for determining mode shapes and frequencies, particularly with regard to dynamic problems in aircraft design, is the relative ease with which it handles complex discontinuous structures whose elastic properties can be defined adequately only in terms of influence coefficients. The disadvantage of tedious calculations has been alleviated greatly by an "acceleration method" for convergence which has been described by Isakson [*J. aero. Sci.* **16,** p. 443, July 1949]. The predominant disadvantage to matrix iteration, however, has been the difficulty in obtaining mode shapes and frequencies higher than the fundamental. The purpose of this paper is to establish a technique for accomplishing this in a manner that is practical for use in industry. This is accomplished by applying a device worked out by L. A. Pipes ["Applied mathematics for engineers and physicists," McGraw-Hill Book Co., Inc., New York, 1946, pp. 191–203], and extending it to the general case, at the same time organizing the computations in tabular form.

From author's summary

951. Sokolnikoff, I. S., Tensor analysis. Theory and applications, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., Oct. 1951, ix + 335 pp. $6.

The present book is addressed to the applied mathematician, physicist, and engineer and contains the usual introductory material that somehow has been accepted by textbook writers as the correct form in which invariant concepts are to be presented to applied mathematicians. The book actually is a conventional introduction to differential geometry, seasoned with a conventional introduction to dynamics and to the mechanics of continuous media. It differs from standard textbooks on physics chiefly in that it leaves out summation signs.

The book is an improvement over McConnell's "Absolute differential calculus" (now out of print) inasmuch as it contains more physics and thereby less geometry. Also, the presentation is unquestionably more polished; the basic equations of elasticity and hydrodynamics appear here stated in their most general tensorial form applicable for nonlinear problems also; besides the equations of Lagrange, those of Hamilton are stated in index notation; even relativity has been given an introductory and satisfactory treatment.

The engineer studies tensor analysis in the hope of learning new physical concepts, new thought-saving devices to enable him to solve problems that conventional methods find too complex or too elusive. Since the reviewer has witnessed a whole generation of engineers wrestle with textbooks on tensors and also has seen them all (except perhaps himself) give up the struggle as hopeless, let him be allowed to add a few remarks on what he considers the undeniable failure of all such texts to put the newly introduced tensorial concepts to practical, everyday use.

In order to apply tensorial methods to the solution of practical problems that could be solved otherwise only with great difficulty, it is necessary to be imbued with an entirely different aspect of tensor analysis than the static "shorthand notation" feature that the present author so unfortunately emphasizes. That aspect is the universal invariance of all natural phenomena, the possibility of passing from simple physical systems to the most complex systems of the same type—and back again—by a mere "transformation," or by a mere replacement of "ordinary" differentiations by "covariant" differentiation.

For instance, tensorial concepts should enable the engineer to generalize his "transformation" concepts of passing from rectilinear to curvilinear reference frames (or from stationary to moving frames) to include also the processes of tearing apart and interconnecting physical structures and their associated tensors. The engineer should be able to solve many complex dynamical problems by simply "freezing" the motion into standstill (or into some simpler motion). After setting up the equations of the stationary system, he should be able to return automatically to his original system by simply replacing ordinary derivatives by covariant derivatives.

Without the utilization of such "dynamical" aspects of tensorial reasoning, the engineer and the applied mathematician will find the study of tensors merely an endurance race with frustration. They will find tensor analysis merely a tedious and never ending recital of a host of geometrical theorems—to them utterly useless—about curves and surfaces immersed in spaces with higher dimensions.

There exists a definite need in applied mathematics and engineering for a "New Deal in tensors" to be put forth by professional mathematicians who are at the same time creative workers in tensors. It is an absolute necessity that such New Dealers should drop geometry and abstract mathematics as vehicles for presenting tensorial concepts and use physics and engineering only as illustrations (except, of course, where geometry itself enters naturally). Also these texts must not merely *recite* the basic equations of dynamics and fluid mechanics in a new notation, as has been done already by countless other writers; rather, they must show how to analyze and solve, by means of the tensorial concepts developed, complex physical and engineering problems that are too difficult to be visualized, analyzed, and solved otherwise. They must show by actual examples how a tensorial point of view simplifies the physical picture of the phenomenon and point out where the tensorial point of view is already used without being aware of the label.

Gabriel Kron, USA

952. Polisar, G. L., The synthesis of mathematical machines and real objects (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **74,** 711–714, 1950.

The method of partial simulation is here considered when the simulator is a high-speed digital computer. Attention is drawn to the errors arising from the circumstance that the computer and unreplaced equipment are interconnected only at a succession of discrete moments between which, for the situation studied here, each proceeds independently from initial conditions furnished by the other. As an example, these errors are estimated and their compensation considered for a feedback system governed by the equations $du_1/dt = u_2 - u_1$, and $du_2/dt = u_1 - u_2$.

Courtesy of Mathematical Reviews R. Church, USA

953. Ackerman, S., Precise solutions of linear simultaneous equations using a low cost analog, *Rev. sci. Instrum.* **22,** 10, 746–748, Oct. 1951.

Author describes a new method of solving linear simultaneous equations to a desired degree of accuracy. He first transforms the system so that the resulting coefficient matrix has prevalent diagonal elements, and then solves the transformed system by the iterative method. The transformation matrix is yielded by a conventional electric analog device for solving linear simultaneous equations; the iterative process is accomplished by a desk calculator. Author attempts, by use of that combination, "to obtain the equivalent of a large-scale digital device."

F. A. Willers, Germany

954. Wood, R. H., A special type of group displacement for use in the relaxation technique, *Quart. J. Mech. appl. Math.* **4,** part 4, 432–438, Dec. 1951.

Paper is concerned with certain technical details of the relaxation method as applied to the numerical solution of the biharmonic equation. M. V. Wilkes, England

955. Allen, D. N. de G., and Dennis, S. C. R., Graded nets in harmonic and biharmonic relaxation, *Quart. J. Mech. appl. Math.* **4,** part 4, 439–443, Dec. 1951.

The number of nodal points required for solving Laplace (or similar) equations can be greatly reduced by using interlaced networks of various sizes. Paper shows that the usual "diagonal" interlacing is satisfactory for the biharmonic equation too. This extension is based on the observation that the biharmonic operator is an iteration of the Laplace operator or $\nabla^4 = \nabla^2 \cdot \nabla^2$.

Andrew Vazsonyi, USA

956. Brown, W. B., and Donoughe, P. L., Tables of exact laminar-boundary-layer solutions when the wall is porous and fluid properties are variable, *NACA TN* 2479, 68 pp., Sept. 1951.

Momentum and energy balance equations of the laminar boundary layer for two-dimensional steady-state compressible flow are transformed to ordinary differential equations by the methods of Pohlhausen, Falkner, and Skan. The latter include

parameters expressing the main stream-pressure gradient, flow through a porous wall, and temperature-dependent property changes across the boundary layer. A total of 58 cases is solved numerically and the results set out in tabular form. The pressure gradients vary from stagnation point values to those occurring at the laminar separation point. Three rates of flow through the porous wall are considered, including the impermeable case and five values of the stream-to-wall temperature ratio. Velocity, weight-flow, and temperature distributions are tabulated as well as the dimensionless stream function of Falkner and Skan and its derivatives and the Pohlhausen function and its derivatives. Each case determines a value for the Nusselt number, the drag coefficient, and the displacement, momentum, and convection thicknesses of the boundary layer.

Lawrence M. Grossman, USA

NBS-NACA Tables of thermal properties of gases, National Bureau of Standards:

957. Woolley, H. W., Helium (Ideal gas state): specific heat, enthalpy, entropy, C°_p/R, $(H^\circ - E^\circ_0)/RT_0$, S°/R, Table 6.10, 4 pp., July 1950.

958. Woolley, H. W., Carbon monoxide (Ideal gas state): specific heat, enthalpy, entropy, Table 14.10, 4 pp., Sept. 1951.

959. Nuttall, R. L., Molecular oxygen: thermal conductivity, k/k_0, **Table 9.42,** 5 pp., July 1951.

960. Nuttall, R. L., Carbon monoxide: thermal conductivity, Table 14.42, 5 pp., July 1951.

961. Nuttall, R. L., Nitric oxide: thermal conductivity, Table 16.42, 3 pp., July 1951.

962. Nuttall, R. L., Freon 12: thermal conductivity, Table 17.42, 4 pp., July 1951.

963. Nuttall, R. L., Argon: thermal conductivity, Table 19.42, 4 pp., July 1951.

964. Nuttall, R. L., Freon 12: coefficients of viscosity, η/η_0, ν/ν_0, Table 17.39, 3 pp., July 1951.

965. Salzer, H. E., Formulas for finding the argument for which a function has a given derivative, *Math. Tables and other Aids to Computation* **5,** 36, 213–215, Oct. 1951.

966. Polisar, G. L., Electrical method for the solution of a certain problem in dynamics of the airplane (in Russian), *Tekhnika Vozdushnogo Flota* no. 7, 15–18, 1947.

Author briefly describes a differential analyzer for solution of up to 6 linear first-order differential equations with constant coefficients. Constructed at the Power Institute of the Academy of Sciences, its basic design, which uses conventional capacity and amplifier integrating circuits, is attributed to L. I. Gutenmaher [*Dokladi Akad. Nauk SSSR* (*N.S.*) **47,** 259–262, 1945]. Errors not greater than the width of the output as shown on an oscillograph are claimed for its solution of a test problem. The behavior of an actual autopilot is investigated by connecting it to the differential analyzer as a model of the plane to be controlled by it.

Courtesy of Mathematical Reviews R. Church, USA

967. Finzi, B., Characteristics of differential systems and wave propagation (in Italian), *Energia elett.* **27,** 4, 189–195, Apr. 1950.

Paper is of value as an introduction to the method of characteristics of solving partial differential equations. Applications of the method are given to the propagation of discontinuities in an ideal compressible fluid, and to waves of finite amplitude on the free surface of the water. Author does not show an aquaintance with literature of these subjects other than French and Italian.

J. M. Jackson, Scotland

968. Pignedoli, A., On a differential equation occurring in the problem of vibrations of a membrane with a fixed epicycloidal contour (in Italian), *Atti Semin. Mat. Fis. Univ. Modena* **4,** 3–25, 1949–1950.

Paper concerns a new set of functions defined by a generalization of Bessel's differential equation, which arises in studying vibrations of a membrane of epicycloidal shape by means of conformal mapping. Several properties and relationships of these so-called epicycloidal functions are derived, notably: Representation by means of an integral equation of Fredholm type, by means of definite integrals involving Bessel functions, by means of hypergeometric functions, and by means of Laplace integrals. The characteristic value problem for the differential equation is reduced to that for an integral equation of Volterra type by means of Green's functions. W. A. Mersman, USA

969. Ruppeneĭt, K. V., On equations of the theory of plasticity for axisymmetrical problems (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **80,** 4, 557–560, Oct. 1951.

Mathematical discussion of the stress and strain differential equations in the case of cylindrical symmetry.

D. ter Haar, Scotland

970. Kantorovich, L. V., and Krĭloff, V. I., Approximate methods of higher analysis [Priblizhennie metodí vísshego analiza], Moscow, Izd. tekh. teor. liter., 1950, 695 pp. $2.50.

Book is the result of many years of work carried out by many Russian scientists in a concentrated effort to create some kind of a "higher practical analysis" for engineers and physicists regularly engaged in the treatment of problems of mathematical physics, particularly in elasticity and hydrodynamics. Since accurate methods can be used productively in exceptional cases only, there is a great need for approximate standard procedures. The earlier devices of this kind are the direct methods of Ritz and Galerkin in problems of the calculus of variations and the method of finite differences in the treatment of differential equations. The practical success of these methods was the stimulus for creation of similar methods in other branches of analysis, and these new methods are incorporated in the book under review. It consists of the following seven chapters: 1. Methods based on presentation of solution in the form of infinite series (pp. 1–109); 2. Approximate solution of Fredholm integral equations (pp. 110–178); 3. Finite differences (pp. 179–257); 4. Variational methods (pp. 258–373); 5. Conformal transformation of regions (pp. 374–563); 6. Principles of application of conformal transformation to the solution of fundamental problems for canonical regions (pp. 564–636); 7. Methods of Schwarz (solution of Dirichlet's problem for the case of a sum of overlapping regions, pp. 637–695). The chapters can be read independently of each other, except chapter 6, which is closely connected with chapter 5. These two chapters are of special interest in view of the great practical importance of the methods of conformal transformation in the process of solution of the plane harmonic and biharmonic problems in mathematical physics in general. The research work presented in this field deserves particular attention, because the authors have largely contributed to developing the possibilities of practical application of conformal mapping [see I. S. Sokolnikoff, "Theory of elasticity," 1946, p. 169]. Book is easily readable; purely mathematical proofs are

omitted, but the general mathematical ideas are well outlined and their practical applications are illustrated by valuable examples. This volume can be warmly recommended to any engineer or physicist interested in problems of the kind indicated, provided, of course, that he understands Russian. It is also a book whose translation into English is, in reviewer's opinion, highly desirable. I. Malkin, USA

971. Flügge-Lotz, I., Mathematical improvement of method for computing Poisson integrals involved in determination of velocity distribution on airfoils, *NACA TN* 2451, 84 pp., Oct. 1951.

In subsonic airfoil design, three-dimensional lifting-line analysis, and the study of supersonic conical-flow fields, the aerodynamicist is repeatedly concerned with the evaluation of Poisson integrals. Paper surveys methods currently used in numerical calculations of such integrals and presents a new method which permits the use of unequal intervals for the variable of integration. Considerable reduction in the tediousness of present techniques is effected. Comparisons of results and detailed instructions for the use of the new method are given.

Max A. Heaslet, USA

972. Miller, K. S., The one-sided Green's function, *J. appl. Phys.* **22,** 8, 1054–1057, Aug. 1951.

Let L be a linear differential operator of the nth order whose coefficients $p_i(x)$ are continuous in a semi-infinite interval I: (a, ∞). A function $H(x, \zeta)$ is said to be a one-sided Green's function for the operator L if it satisfies the four conditions: (1) H is continuous and its first n derivatives with respect to x are continuous in I; (2) $H_\alpha(\chi, \zeta) = 0$ for $\alpha = 0, 1, \ldots, n-2$; (3) $H_{n-1}(\chi, \zeta) = 1/p_0(\zeta)$; (4) $LH = 0$. (The subscript on H refers to partial differentiation with respect to the first argument, and $p_0(x)$ is the coefficient of d^n/dx^n in the expression for L). It is shown that H is unique and if $u(x) = {}_a\int^x H(x, \zeta)f(\zeta)d\zeta$, then $Lu = f(x)$ and $u^\alpha(a) = 0$, $\alpha = 0, 1, \ldots, n-1$. Furthermore, if H is given, a fundamental system of solutions of $Lu = 0$ can be written down explicitly in terms of H and its derivatives evaluated at the end point a. The converse problem is trivial. Other properties of H are also considered; for example, its relation to the impulsive response of a network.

From author's summary by A. W. Jacobson, USA

973. Buzzard, R. W., and Cleaves, H. E., Hydrogen embrittlement of steel. Review of the literature, *Nat. Bur. Stands. Circ.* 511, 29 pp., Sept. 1951.

974. Tanaka, S., Measurement of the thickness of metal plate by ultrasonic harmonic method. I. On the condition of thickness resonance. II. Electronic operation and results of a field inspection, *Sci. Rep. Res. Inst. Tohôku Univ. (A)* **2, 3;** 6, 2; 917–924, 201–208; Dec. 1950, Apr. 1951.

Paper refers to the method of standing waves set up in the metal plate by an excited quartz crystal. [See N. G. Branson, *Electronics*, **21,** 88–91, Jan. 1948.] Author points out that crystal and metal plate should be loosely coupled by an oil film. A formula of frequency deviation referring to standing waves and neighboring resonance of the whole mechanical vibration system is derived from the electric circuit equivalent (two damped oscillatory circuits with loose capacitive coupling). Formula makes it possible to choose the thickness of the oil film and the order of standing waves so as to keep the deviation below a given tolerance. Indication of a resonance frequency is given by a peak of plate current of a variable frequency oscillator exciting the quartz crystal. A special oscillator of the homodyne-detector type is fully described and a great number of thickness measurements of penstock walls discussed. The error is less than 6%. Influence of shape, slope, corrosion, etc., of the reverse side of the metal plate is also considered. Hans Bückner, Germany

Mechanics (Dynamics, Statics, Kinematics)

THE FOLLOWING ARTICLES (REVS. 975–994) APPEARED, IN RUSSIAN, IN *Trudi Sem. Teor. Mash. Mekh*:

975. Kreĭnes, M. A., The coefficient of efficiency and the transmission ratio of compound gear trains, 1, 21–48, 1947.

Paper deals with gear trains consisting of a number of simple (three-member) epicyclic (planetary) trains, $K_1, \ldots, K_n$ whose arms (i.e., the members connecting the axles) rotate about fixed axes. Only torques are assumed to act at the members, and friction only between the teeth is considered. If i_q is the train ratio (with the arm at rest) of K_q, the over-all transmission ratio is $i = f(i_1, \ldots, i_n)$ where f is a quotient of two linear functions. If η is the efficiency, $\eta = f(i_1\eta_1^{\pm 1}, \ldots, i_n\eta_n^{\pm 1})/f(i_1, \ldots, i_n)$ where the exponent of η_q depends on which of the two wheels of K_q is driving. If all η_q are close to 1, the exponent of η_q is sgn j_q, where $j_q = \partial \log |i| / \partial \log |i_q|$. In this case $\eta \approx 1 - \Sigma |j_q| (1 - \eta_q)$. Several numerical examples are given. In general, j_q is the fraction of power lost in K_q. A general method for the determination of f is given in chap. 3. The argument is valid also for spatial gear trains. A. W. Wundheiler, USA

976. Dobrovol'skiĭ, V. V., On the coefficient of efficiency of compound gear trains, 1, 59–69, 1947.

The results of the preceding paper are stated (independently) in less general terms. A. W. Wundheiler

977. Kreĭnes, M. A., and Rozovskiĭ, M. S., A sketch of the angular velocities in a gear box with two degrees of freedom without a fixed external support against rotation, 2, 5–16, 1947.

Transmissions of two degrees of freedom, capable of rigid rotation with the driving shaft, are considered. It is assumed that each transmission ratio i_q is enforced by locking a gear wheel q. In general, its angular velocity (1) $\omega_q = a_q\omega_0 + b_q\omega_\infty + \ldots$, where ω_0 and ω_∞ are the input and output speeds. In the plane (ω_∞, ω) the straight line (1) intercepts on the ω_∞-axis the ratio i_q, and goes through the point (ω_0, ω_0). The graph of all the equations (1) is the author's "plan of angular velocities." It can also be used for the determination of the moments on the several wheels. A. W. Wundheiler

978. Kudryavtsev, V. N., An investigation of planetary gears, 3, 11, 38–63, 1947.

A systematic terminology and classification is given for plane planetary gear trains, but its exhaustiveness is not discussed. The transmission ratios and their variations are considered. Two thirds of the paper is devoted to a determination of efficiency coefficients, assuming that the arm (= center line of the gear train) is at rest. In fact, "efficiency of planetary trains" would be a more useful title for the paper. A. W. Wundheiler

979. Gessen, B. A., The analytical method of investigation of spatial meshing, 5, 19, 22–61, 1948.

Chapters 1 and 2 contain a review of the kinematics of a moving surface in parametric treatment. Both vector and coordinate symbolics are used. Envelope equation and relative motion are emphasized. Chapter 3 (5 pp.) rewrites Gohman's equations ["Teoriya zatsepleniĭ," Odessa, 1886] of mating surfaces obtained

as the two envelopes, relative to the two meshing bodies, of any moving surface. The equations of the characteristics are also given. These equations are of the first order in the partial derivatives of F, where $F(X, Y, Z) = 0$ is the equation of the surface in question. In chapter 4 (9 pp.) the equations for the same surfaces and characteristics are derived assuming parametric representation; their left-hand sides are written as determinants. The whole discussion is made in general terms. Most readers would probably be satisfied if they could see the last nine pages only. The developments are applied in the paper of the following review. A. W. Wundheiler

980. Gessen, B. A., and Zak, P. S., Globoidal meshing, 6, 27–49, 1949.

A globoidal (hourglass) worm gear is considered. The surface of the worm is generated by a straight line tangent to the worm wheel and intersecting the worm axis (perpendicular to the wheel axis) while both revolve uniformly. The equations of both mating surfaces and the lines of contact are developed by the method described in the preceding review. Because of undercutting, only one part of the tooth surface is an envelope of the mating surface. There are two other parts whose equations are also given. It is shown that there is a tooth with which the worm has three simultaneous lines of contact. With other teeth, there are two or one lines of contact. Clear diagrams illustrate these facts.
A. W. Wundheiler

981. Geronimus, Ya. L., An application of the method of best approximation to balancing, 4, 14, 64–67, 1948.

For a rotating crankshaft (α is crank angle), author introduces complex numbers in the plane perpendicular to its axis. If p and m_{xy} are then the resultant vector and moment after application of counterbalances, the best mean balancing occurs when $\int |p|^2 d\alpha$ and $\int |m_{xy}| d\alpha$ are simultaneously minima. The best uniform balancing occurs when max $|p|$ and max $|m_{xy}|$ are minima. For two counterbalances, the resulting equations can be solved with ease in terms of centers and centers of gravity of certain representative points of the complex plane. A. W. Wundheiler

982. Geronimus, Ya. L., On the calculation of the counterweights of a crankshaft to reduce the bearing loads, 2, 164–174, 1947.

The method of the preceding paper is applied to the problem of bearing loads. The mean-square reactions ($\int_0^{4\pi} K^2 d/4\pi$) are minimized. It is found that the counterweights should balance the load component that rotates with the crankshaft. The problem is reduced to a set of linear complex equations. For a six-throw crankshaft, the equations are solved for four and six counterweights. For a four-throw crankshaft a set of three weights is computed. A numerical illustration is given for the Curtiss Conqueror engine. A. W. Wundheiler

983. Yudin, V. A., A theory of a planetary, pin-tooth, internal-gear transmission, 4, 13, 42–77, 1948.

The outer wheel of an internal-meshing planetary (hypocyclic) gear train is pin geared (the teeth are circular). The pin radius is such that the pitch point is never the point of contact. The profile of the inner wheel is determined as a parallel to a lengthened pericycloid, and two other generations of this profile are given (a parallel to a hypocycloid, and a four-bar curve). The (indeterminate) dynamics of the transmission, and its several losses are discussed. The design problem is assessed. Simplicity of gear production is claimed, as well as advantages for use at high transmission ratios. There is a numerical design example.
A. W. Wundheiler

984. Gerasimov, Yu. N., A generalized theory of radial and nonradial Geneva-stop mechanisms, 4, 15, 20–48, 1948.

Geneva-stop mechanisms are generalized by allowing the slots to be nonradial and nonuniformly spaced. Several driving pins become necessary, and special circular exit slots must be provided, the exit occurring during the rest period. Relations are derived between the numbers of slots and pins and the durations of motion and rest periods. The slot design for shockless operation is discussed. With nonradial slots, the shaft separation L can be kept constant while the driven member is varied. The offset of the nonradial slot is determined as a function of L and the number of slots when they are evenly spaced. Formulas are derived for the angular velocity and acceleration of the driven member, and a detailed discussion is made of their variation. Two design examples are given. A. W. Wundheiler

985. Dobrovol'skiĭ, V. V., On statically indeterminate mechanisms, 5, 18, 24–33, 1948.

Statically determinate mechanisms are defined here relative to a force system (F) as such for which all reactions are determined when the force system (F) is given, the inertial forces neglected, and the deformations of the rigid members neglected. Examples are given, and also a classification of mechanisms (according to possible translations and rotations of their members) together with a statement of the force systems relative to which the mechanisms are statically determinate. This classification is too cryptic for this reviewer to report on. A. W. Wundheiler

986. Zinov'ev, V. A., The energy method for the study of machinery motion, 4, 15, 49–65, 1948.

The equation of motion of machinery driven by a prime mover (of parameter ϕ), rotating with an angular velocity ω, is written in the form $M_d + M_r = d(\frac{1}{2} I\omega^2)/d\phi$. Eight cases are singled out in terms of the single variable (ϕ, ω, or t) on which M_d, M_r, or I is assumed to depend. Subcases of integrability are pointed out.
A. W. Wundheiler

987. Shitikov, B. V., and Shchepetil'nikov, V. A., On the number of satellites in planetary transmissions, 6, 21, 50–68, 1949.

Let 1 and 4 be two coaxial gear wheels, and let the compound satellite consist of two solid, keyed, coaxial gears 2 and 3, 3 meshing with the fixed gear 4, and 2 with 3. Then the number of satellites compatible with the gears 1 and 4 is $p = iz_1/mz_3$ where i is the transmission ratio between the arm and the gear 1, z the number of teeth, and m any common divisor of z_2 and z_3. An inverse problem (p and i given) is also discussed, as well as the logic of the assembling procedure. A. W. Wundheiler

988. Kobrinskiĭ, A. E., On kinematic errors of mechanisms in nearly extreme positions, 9, 33, 29–38, 1950.

If $\Delta\omega = \Sigma' a_s \Delta l_s + R$, where Δl_s are some fundamental errors and R is, at least, of order two in Δl_s, then, near a position where not all a_s are finite, author vaguely advocates max $|R|/\Sigma a_s \Delta l_s$ as a measure of accuracy. The presentation is awkward.
A. W. Wundheiler

989. Dobrovol'skiĭ, V. V., On bevel gearing, 2, 127–140, 1947.

The principles of bevel gearing are reviewed, and octoid and spherical involute teeth considered. For the octoid form, the equations of the tooth outlines, and the end points of the active section of the line of contact are determined. For the involute form, the minimum number of teeth without undercutting is determined, as well as the coefficient of overlap. There is some dis-

cussion of internal meshing and associated interference phenomena. The method is strictly analytic. Part of the paper must be regarded as expository. A. W. Wundheiler

990. Kolchin, N. I., A skew worm gear with arbitrary angle of the axes, 3, 9, 18–51, 1947.

Author attaches a Cartesian coordinate system to each element of the gear, and derives the mating surface and the characteristic lines (of contact) for (1) a convolute surface (generated by a straight line in helical motion); (2) its special case, the evolvent surface (the straight line is tangent to the helix described by its central point); and (3) another special case, the Archimedean surface, when the straight line intersects the axis of the helical motion. The developments are given in complete detail. Numerical examples and diagrams of the contact lines are given.
A. W. Wundheiler

991. Geronimus, Ya. L., Motions with a minimum peak acceleration, 4, 15, 66–91, 1948.

The time of motion T and the distance traveled h are given; there is rest at both ends of the run. Author proves first that the peak is a minimum if the acceleration w is $\pm 4h/T^2$ during the first and second half of the motion, respectively. Continuous accelerations arbitrarily close to this peak can be found. Using Chebíshev's method of best approximation, and assuming the motion symmetric about $t = \frac{1}{2}T$ with $w(\frac{1}{2}T) = 0$, author finds complete solutions for 18 combinations of the following conditions in $0 \leqq t < \frac{1}{2}T$:

(1a) w is a polynomial in t of degree $n \leqq 3$;

(1b) $w = A + B\cos\phi + C\cos 2\phi + D\cos 3\phi$, $\phi = \pi t/T$;

(2a) $w > 0$; (2b) $w > 0$, $w' \leqq 0$; (2c) $w \geqq 0$; $w' \geqq 0$; $w'(0) = 0$;

(2d) $w > 0$, $w' < 0 w'' \geqq 0$. For polynomials of degree three, the condition of given maximum velocity is combined with (2a), (2c), and (2d). The results are neatly tabulated.
A. W. Wundheiler

992. Geronimus, Ya. L., On some problems in the synthesis of cam mechanisms, 5, 19, 62–81, 1948.

Author continues his study of runs with a minimum peak acceleration. The distance h, the time T, the maximum speed V_0 are given; the velocity V and acceleration W are continuous and vanish at the beginning and at the end of the run; and the (W, t) curve is symmetric about the point $(0, \frac{1}{2}T)$. A solution of the form $a_1 \sin\phi + a_2 \sin 2\phi + a_3 \sin 3\phi$, $\phi = 2\pi t/T$ is determined to yield a minimum over-all acceleration peak, assuming $W(t) \geqq 0$ for $t < \frac{1}{2}T$. Familiar methods are used, and considerable labor expended. Next, the symmetry condition is replaced by prescribing the value of the area under the distance-time curve, and a minimum peak of deceleration demanded. Expressions of the type $a_1 \sin\phi + a_2 \sin 2\phi$, ϕ linear in t, are used for the acceleration and deceleration periods. As in the first problem, the analysis of some inequalities makes the procedure very laborious.
A. W. Wundheiler

993. Geronimus, Ya. L., Concerning the design of some cam mechanisms with piecewise circular cams, 5, 17, 69–79, 1948.

Author continues his work on minimum problems. Cam (A) is translatory of velocity v_1 and two circular arcs separated by a straight line segment. Cam (B) rotates at a speed ω and consists of three circular arcs. For cam (A) the velocity v_1 of the follower is given; for cam (B) the angular velocity ω. In both cases the travel time T and distance h of the follower travel are given. Three types of problems are considered: (1) Minimize the absolute peak acceleration w_0; (2) given the ratio w_1/w_2 of the peak acceleration w_1 and peak acceleration w_2, make w_2 a minimum; (3) given the absolute peak velocity v_0, minimize the absolute peak acceleration w_0. The choice of the type of problems is justified by practical considerations. Complete solutions of the six problems involved are presented. A. W. Wundheiler

994. Zhegalov, L. I., A method of geometric loci for the design of the smallest cam for a given plane follower, 6, 21, 69–71, 1949.

Twelve positions of the follower determine twelve sides of a polygon approximating the cam, after the center of the cam is chosen on the axis of the follower. As this center is varied, the locus of a vertex of the polygon is a straight line. The loci of the end points of the smallest side intersect in a point. The corresponding polygon has (in the limit) the smallest diameter.
A. W. Wundheiler

995. Marstrand, O. J., and Shearlaw, J. B., Prevention of castor shimmy by the twin-contact tyre, *Aero. Res. Counc. Lond. Rep. Mem.* 2508, 15 pp., Mar. 1942, published 1951.

The development of a twin-contact tire for the suppression of shimmy phenomenon in castoring wheels is presented. Some theoretical considerations demonstrate the feasibility of such tires. The twin-contact tires are considered as double disks. The ratio of damping for the double-disk system to that of the single-disk system is shown to be approximately $(c^2 + b^2)/c^2$, where c is the castor length and b is half the distance between the contacting treads. The effective stiffnesses of the tire in the radial, tangential, and lateral directions are all much higher for the twin-contact tires when compared to a corresponding conventional tire. Actual service tests have indicated that shimmy problem on tail and nose wheels of airplanes may be completely overcome by twin-contact tires without any other form of damping devices.
Conrad C. Wan, USA

Gyroscopics, Governors, Servos

(See also Rev. 1116)

996. Heinrich, G., New investigations of the rolling error of monogyrocompasses (in German), *Öst. Ing.-Arch.* **4**, 3–4, 215–221, 1950.

The cause for the rolling error of the Anschuetz monogyrocompass was determined for the first time by M. Schuler. Author's investigation gives a general theory of the rolling error, which can be applied to all systems of monogyrocompasses. In addition, the so-called "conical rolling," which appears when the rolling plane does not remain stationary, has been investigated. This type of rolling causes an error which is independent of the course, while "plane rolling" produces errors dependent on the course. The Anschuetz monogyrocompass is not subject to error due to conical rolling, while the Sperry and Brown compass systems produce both course-dependent and course-independent errors. From author's summary

997. Greiner, E., The control pump and its application in power engines (in German), *ZVDI* **93**, 29, 921–925, Oct. 1951.

Author describes a pump with rotating pistons, the delivery of which can be regulated in limits from $+Q_{max}$ to $-Q_{max}$. It is shown that, in servo-governing, such a pump makes the regulating valve superfluous, the delivery of the pump being controlled by the control device; for example, by a speed governor. In this way losses, and thus input, of the servo governor are reduced and the

whole equipment is simplified. In a schematic way, interesting examples are described for control of ship propellers and for governing water turbines.

Miroslav Nechleba, Czechoslovakia

998. St. Clair, D. W., Coombs, W. F., Jr., and Owens, W. D., Frequency response analysis for industrial automatic control systems, Ann. Meeting ASME, Atlantic City, Nov. 1951, Paper no. 51–A-127, 22 pp., 23 figs.

Report applies some of the frequency response methods developed for servomechanism analysis to representative industrial control systems. Authors translate the material into the language of the industrial engineer, using almost no mathematics. Analyses show how gain, derivative time, reset rate, transportation lag, and capacity lag in industrial control are related to period of oscillation and stability. Emphasis is on polar plots of transfer functions together with M circles. Although graphs of log attenuation phase angle against log frequency, and log gain vs. phase angle appear to be more popular among servoanalysts, the paper does not recommend a specific method but rather endeavors to explain the frequency-response idea. Industrial engineers may find the paper especially helpful because of the free use of industrial control language which is notably absent in the more recent servomechanism books. Herbert K. Weiss, USA

999. Zadeh, L. A., A note on the initial excitation of linear systems, *J. appl. Phys.* **22,** 9, 1216–1217, Sept. 1951.

A modification of a previous paper [See AMR **5,** Rev. 26], covers the case where the initial values of the response and its derivatives are given for $t = 0$. A. W. Wortham, USA

Vibrations, Balancing

(See also Revs. 950, 968, 1225)

1000. Thornton, D. L., Mechanics applied to vibrations and balancing, 2d ed., London, Chapman & Hall, Ltd., 1951, xii + 584 pp. 50s.

This second edition [treatise published originally in 1940 and reviewed in *J. appl. Mech.* **9,** p. A-50, 1942] differs from the first primarily by the addition of a new chapter on the dynamic loading of structures, and by a rewriting of the "General survey" chapter. The scope of the book can best be indicated by its chapter headings: I. Balancing of engines; II. Balancing of locomotives; III. Theory of vibrations; IV. Propagation of stress in elastic materials; V. Beams and plates; VI. Rotating shafts and discs; VII. Dynamic loading of structures; VIII. General survey.

The first two chapters present a very detailed analysis of the problems of balancing engines and locomotives. Horizontal, vertical, vee, and radial engines are analyzed; the dynamics of various locomotive engine arrangements and valve gears are developed. Free use is made of generalized coordinates and Lagrange's equations. Some space is devoted to the stability and testing of governors.

In general, other topics common to books on vibration theory are treated by classical methods. These include beams, struts, membranes, plates, torsional vibrations of branched and geared systems, critical speeds, gyroscopes. Author expresses a preference for the Lagrangian approach and uses it wherever possible. The Rayleigh method is also used, particularly when dealing with rigid-jointed structures and bars of variable section. The theory of propagation of elastic waves is applied to pile driving, stress waves in composite materials (e.g., reinforced concrete), water hammer, seismic waves, and transmission of wave power. Plastic strain-wave propagation is outlined briefly in conjunction with Hamilton's equations of motion.

Author presents general discussions of problems concerned with failures in structural connections and ship's machinery from nearby explosions, with ship vibration, with the relations of subsoil, foundations, and superstructure to earthquake effects, with airplane and propeller vibrations, and with turbine wheel vibration.

Book provides many interesting applications not usually found in other volumes on mechanical vibrations, although it also omits some practical techniques such as the Stodola and Holzer methods. Walter W. Soroka, USA

1001. Kanai, K., and Yoshizawa, S., Relation between the earthquake damage of non-wooden buildings and the nature of the ground. I, II, *Bull. Earthq. Res. Inst., Tokyo Univ.* **27, 29;** 1/4, 1; 97–100, 209–213; Dec. 1949, Mar. 1951.

In Part I, the senior author investigates statistically the earthquake damage to ferro-concrete and brick buildings with the aid of the data in the former Tokyo City at the time of the Kwanto earthquake of 1923. He finds that the harder the ground the severer the damage, and that the first floor is most severely destroyed in firm ground, while in soft ground the upper floors are severely damaged. These results might be explained by taking into consideration the fact that the vibration energy dissipates to the ground again as elastic waves starting from the foundation. The data are mathematically examined in part II, while the relation between earthquake damage and the ratio of the height to the sectional area of the buildings is also explained satisfactorily. Authors conclude that the dissipation of vibration energy from the foundation is important for earthquake-proof problem of structure. Tsuneji Rikitake, Japan

1002. Schindler, A., Effect of the suspension in a ground vibration test (in French), *Rech. aéro.* no. 24, 61–66, Nov.-Dec. 1951.

In reviewer's opinion, this is an excessively mathematical analysis with no novel conclusions. J. H. Greidanus, Holland

1003. Magnus, K., Forced vibrations of a linear oscillator under nonharmonic excitation (in German), *ZAMM* **31,** 10, 324–329, Oct. 1951.

Forced vibrations of linear, damped oscillator are determined from solution for free vibrations. Three types of excitation are considered: (1) Constant force changing direction periodically; (2) impulse changing direction periodically; and (3) periodic impulse in one direction. Period of excitation is basis for relations between displacements and also velocities. These kinematic relations determine portion of free decay curve to be used in solution. Results are obtained in closed form indicating advantage over Fourier analysis for numerical computation.

Robert P. Felgar, Jr., USA

1004. Gassmann, F., On damping through radiation of elastic waves and on damped vibrations of rods (in German), *ZAMP* **2,** 5, 336–356, Sept. 1951.

Paper deals with forced vibrations in supported bodies, applicable, for instance, to structures on ground. Damping is effected by radiation through support, inner and outer damping. Dynamic complex spring constant at support defines radiation damping. Semi-infinite bar and infinite space are treated as supporting bodies. Inner damping is described by linear relation between stress and strain tensors and their time derivatives, including Maxwell, Voigt, and Jeffreys body as special cases. Outer damping due to friction at free surface is chosen proportional to

velocity. Longitudinal, flexural, and torsional vibrations in supported bars are treated in detail, and experimental method of evaluating elastic and damping constants is proposed.

Sverker Sjöström, Sweden

1005. Volterra, E., On elastic continua with hereditary characteristics, *J. appl. Mech.* **18,** 3, 273–279, Sept. 1951.

General equations of motion are deduced. Assuming the heredity function is representable by a Dirichlet series whose number of terms determines the degree of heredity, theory is applied to vibrations of sphere, bar, string, and membranes, all having first-degree heredity damping. Solutions are products of classical solutions and time functions obtained from certain type of integrodifferential equation. Reviewer believes paper may be of value in assessing time-lag effects in mechanical systems under forced vibrations. J. R. M. Radok, England

Wave Motion, Impact

(See also Revs. 1081, 1169)

1006. Carry, C., and Chapus, E., Practical computation of the amplitude of diffracted waves leeward of a semi-infinite breakwater, *Wwys. Exp. Sta. Transl.* 51-11, 10 pp., Nov. 1951.

See AMR **4,** Rev. 3598.

1007. Press, F., and Ewing, M., Propagation of elastic waves in floating ice sheet, *Trans. Amer. geophys. Un.* **32,** 5, 673–678, Oct. 1951.

The characteristic equation for propagation of elastic waves in a floating ice sheet is derived and discussed, with special emphasis on evaluation of phase velocity for very large and very small wave lengths. Solutions cannot be reduced to symmetric and antisymmetric modes as in the case of a plate in vacuum or liquid. Among waves discussed are compressional, shear, longitudinal, flexural, Rayleigh, Stoneley, and Love waves.

From authors' summary

1008. Roseau, M., Gravity waves in liquid of variable depth (in French), *C. R. Acad. Sci. Paris* **233,** 16, 844–845, Oct. 1951.

Author presents a condensed solution in terms of potentials to represent the small harmonic two-dimensional movements of liquid in a channel of which the depth upstream and downstream is either constant or variable. One of the special cases contained in the solution is that of a sloping beach bordering on a body of fluid of essentially constant depth. This article is one of a series by the same author [AMR **4,** Revs. 2765, 4343, 4344]. The assumptions used, including that of irrotational motion of particles, make this a rather academic solution.

W. C. Johnson, Jr., USA

1009. Roseau, M., Solution of functional equations appearing in the problem of gravity waves in liquid of variable depth (in French), *C. R. Acad. Sci. Paris* **233,** 17, 916–917, Oct. 1951.

This is a continuation of the preceding article.

W. C. Johnson, Jr., USA

Elasticity Theory

(See also Revs. 1005, 1234)

1010. Mandzhavidze, G. F., On a singular integral equation with discontinuous coefficients and its applications in the theory of elasticity (in Russian), *Prikl. Mat. Mekh.* **15,** 3, 279–296, May-June 1951.

Author investigates a singular integral equation

$$A(t_0)\varphi(t_0) + \frac{B(t_0)}{\pi i}\int_L \frac{\varphi(t)dt}{t - t_0} + \int_L k_1(t_0, t)\varphi(t)dt + \int_L k_2(t_0, t)\varphi(t)dt = f(t_0)$$

containing in addition to the unknown function $\varphi(t)$ its complex conjugate. The functions $A(t)$, $B(t)$, $k_1(t_0, t)$, $k_2(t_0, t)$, $f(t_0)$ are permitted to have discontinuities of a certain type, and the contour L consists of a finite number of nonintersecting simple closed contours bounding a connected domain in the plane of the complex variable t. Results are applied to the solution of equations arising in the fundamental mixed boundary-value problem of plane elasticity, and are illustrated by the problem of deflection of a thin isotropic elastic plate (subjected to the action of normal load) part of whose boundary is clamped and part is free.

I. S. Sokolnikoff, USA

1011. Fichera, G., On a possibility of determining the physical consistency of the equations of the mathematical theory of elasticity (in German), *ZAMM* **31,** 8/9, 268–270, Aug./Sept. 1951.

The author considers a class of problems in the theory of partial differential equations which includes as special cases the general mixed boundary-value problem, both for potential theory and for classical elasticity theory. Employing the notion of a complete orthonormal system in a normed linear function space, he outlines a proof of existence and uniqueness. The author states that, in the case of elasticity theory, assumption of arbitrary differentiability of the applied surface forces is not sufficient to insure that the displacements possess continuous first partial derivatives throughout the entire body and its surface. For the case of potential theory, the author states that a certain formal average orthogonality condition must be satisfied by a part of the boundary data if the solution is to possess continuous first partial derivatives, and he gives an illustration. He states that determination of the physical meaning of his condition is a problem of mathematical physics, and that if his condition has no physical meaning at all, then one must regard the customary formulation of the problem of elastic equilibrium as illusory. The reviewer is unable to determine whether or not the author makes any use of the fact that the entire surface and extraneous load system, including not only the prescribed surface loads but also those resulting on the part of the boundary where the displacement is prescribed, must form a system in equilibrium.

C. Truesdell, USA

1012. Föppl, O., Limits of validity of Hooke's law of proportionality (in German), *Mitt. Wöhler-Inst.* no. 45, 52 pp., 1951. DM 4.

1013. Föppl, O., The natural elasticity constants E_0 and G (in German), *Bauingenieur* **26,** 8, 244–247, Aug. 1951.

1014. Lekhnitskiĭ, S. G., Theory of elasticity of an anisotropic body [Teoriya uprugosti anizotropnogo tela], Moscow, Gosud. Izd. Tekh.-Teor. Lit., 1950, 299 pp.

This monograph is principally concerned with a systematic presentation of recent contributions in the domain of linear anisotropic theory of elasticity made in the USSR. Chapter 1 (66 pp.) contains a discussion of the basic concepts of anisotropic theory of elasticity and culminates in the formulation of general equations governing the behavior of anisotropic media. Chapter 2 (20 pp.) reviews the simplest cases of stress distribution in anisotropic rods and plates, such as considered by W. Voigt

["Lehrbuch der Kristallphysik," Leipzig and Berlin, Teubner, 1910]. The remaining four chapters (206 pp.) contain a condensed summary of recent contributions. The state of stress in a homogeneous anisotropic cylinder subjected to the action of forces in the plane normal to the axis of the cylinder and not varying along the axis, is analyzed in chapters 3 and 4. The special case of cylindrically anisotropic media is presented in some detail. In chapter 5, the equilibrium of a cantilever beam of uniform cross section under a load on its free end is discussed; several problems involving symmetric deformation and torsion of bodies of revolution are treated in chapter 6.

The monograph contains no discussion of deflection and stability of anisotropic plates, but these problems have been treated in the author's earlier book, "Anisotropic plates" [Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1947]. A stress analyst working with anisotropic media will find this book highly useful because of many explicit design formulas included in it. The bibliography contains 56 items, 45 of which are in the Russian language. I. S. Sokolnikoff, USA

1015. Green, A. E., and Shield, R. T., Finite extension and torsion of cylinders, *Phil. Trans. roy. Soc. Lond.* (*A*) **244,** 876, 47–86, Oct. 1951.

Problems considered are of first- and second-order twisting of uniform elastic bars after finite extension, or hydrostatic pressure, or both. Basic equations as derived in AMR **4,** Revs. 1037, 588, use original and final Cartesian coordinates, but also intermediate general coordinates (particularized later for convenience) in terms of which a strain tensor is defined. In the first part, use of a particular stress-strain law is avoided by taking general strain-energy function of three strain invariants, its derivatives with respect to these invariants, and derivatives of the invariants with respect to strain tensor components. All problems are solved in approximation by assuming forms for displacements suggested by earlier investigations of many authors cited, then showing that equilibrium and boundary conditions can be satisfied. First and second powers of twist are retained. General formulas are found for torsional rigidity of cylinder of any shape as affected by (a) initial finite extension, generalizing result of Rivlin for circular cylinder, (b) initial hydrostatic pressure, with or without extension.

In second part, material is incompressible, having Mooney's strain-energy function (linear in two strain invariants) for rubber-like materials. Assumed second-order terms in pure torsion are found to satisfy all conditions, and effect of change of axis to a parallel axis is examined. Same problem is done also in complex variables, leading to a method similar to Muskhelishvili's for two-dimensional linear problems, requiring mapping function for section and unit circle. Applications are worked out for cardioid, epitrochoid (curvilinear polygon), and inverse of ellipse with respect to center. Similar analysis is given for second-order torsion following finite extension with detailed results for ellipse. Paper is a coordination and extension of finite deformation and initial stress theory. J. N. Goodier, USA

1016. Platone, M. G., On the state of plane stress in a cylindrical elastic body (in Italian), *Ann. Scu. norm. sup. Pisa* (*III*) **5,** I–II, 57–70, Jan.-June 1951.

States of plane stress in a circular cylinder, where all stress components in direction of cylinder (z-) axis vanish, may be determined if normal component of surface forces be given independent of z on the boundary. Said problem is attacked, using method by A. Ghizzetti [AMR **4,** Rev. 1035]. For harmonic function φ and ψ considered, integrals similar to that of Poisson in potential theory are used. Authoress neglects volume forces and puts $\Phi = 0$. Explicit expressions for stress components referred to polar coordinates and for axial displacement are given in closed form. Folke K. G. Odqvist, Sweden

1017. Poritsky, H., and Horvay, G., Stresses in pipe bundles, *J. appl. Mech.* **18,** 3, 241–250, Sept. 1951.

For purposes of stress analysis, a closely packed bundle of many pipes can be replaced by a homogeneous but nonisotropic solid. Paper deals with the derivation of the elastic constants for such a solid, the solution of its stress problem under certain conditions, and the conversion of the results into stresses and displacements of individual pipes. As an example, the thermal stresses are determined that arise in a pipe bundle due to a non-uniform axial temperature gradient.

From authors' summary by H. D. Conway, USA

Experimental Stress Analysis

(See also Rev. 1087)

1018. Bristow, J. R., Metcalf, P., and Mills, C. H. G., The use of wire-resistance strain-gauges in automobile engineering research, with particular reference to the measurement of strain in vehicle structures, *Instn. mech. Engrs. Auto. Div. Proc.* part II, 27–37, 1950–1951.

Static strains in the rims of vehicle wheels due to tire inflation and steady axle loads were measured with wire-resistance strain gages. Dynamic strains at various points in the frame and superstructure of a double-deck passenger vehicle were recorded under road conditions. Sample records are shown, and details of a four-channel carrier-type system using photographic recording with cathode-ray tubes, which was specially developed for these measurements, are given. Reviewer believes that instruments now commercially available would be more suitable for this work.

Donald E. Hudson, USA

1019. Majors, H., Jr., Characteristics of wire gages under various conditions, *Proc. Soc. exp. Stress Anal.* **9,** 1, 123–139, 1951.

Variation of gage sensitivity for SR-4 wire gages, types A-3 and A-15, mounted on steel and constantan, was determined for a temperature range of −310 F to 140 F. Gages were affixed to beams in pure bending, using standard techniques, and were waterproofed with Halowax. They were subjected to strain inside an insulated stainless-steel box with hollow walls, cooled by liquid nitrogen. Author shows that for the temperature range cited, the gage factor is constant for temperature compensation by active gages. When comparing gage factors determined by three temperature-compensation methods, results did not vary more than 1% except for a few instances at temperatures below −100 F. Data on zero shift, after prestressing, showed that the drift was negligible for A-15 gage mounted on steel with an active gage as compensator. Appreciable zero shift occurred for other test conditions. Data are also given for A-15 and AB-1 gages under zero mechanical stress, subjected to cycles of temperature variation and time. Test techniques are excellent, but results naturally are limited to the types of gages employed.

E. O. Stitz, USA

1020. Carpenter, J. E., and Morris, L. D., A wire resistance strain gage for the measurement of static strains at temperatures up to 1600° F., *Proc. Soc. exp. Stress Anal.* **9,** 1, 191–200, 1951.

The construction and use of a high-temperature wire-resistance strain gage suitable for measuring static strains are described. The gage, which is constructed of 0.001-in. Nichrome V wire, spot-welded to 0.010-in. lead wires of the same material, is fabri-

cated with Quigley 1920 high-heat-resistant paint and Sauereisen Cement 1.

Tests show that the gage indicates the strain due to an applied stress when other apparent strain-producing parameters are held constant. The electrical response of the gage is linear with strain within the elastic range of the specimen material. The gage factor varies from about 2.0 at room temperature to about 1.6 at 1250 F and about 1.0 at 1600 F. The gages fail at about 1% tensile strain at 1500 F. For any given temperature, the gages can be calibrated after mounting on the specimen or structure by measuring the electrical response to a known direct tensile stress, the modulus of elasticity being known. The indicator described has a built-in galvanometer which indicates strain directly to 2 microinches as the 6 volt d-c source is connected to each of 48 bridges. The response of the gages to dynamic stresses at elevated temperatures has not been investigated. Typical results show the gage in its present form to be a very useful tool for determining the mechanical properties of engineering materials and structures. Methods of improving the gage are discussed.

B. L. Wilson, USA

1021. Jessop, H. T., and Snell, C., Photoelasticity and aircraft design, *Aero. Quart.* **3,** part 3, 161–172, Nov. 1951.

Purpose of paper is to acquaint the aircraft industry with the increased potentialities of photoelastic stress analysis due to recent advances in methods and scope. The stresses in a Spitfire elevator hinge bracket were analyzed photoelastically by means of a Marco model cast to shape. The stresses were "frozen" into the model and suitable slices removed for study, using ordinary photoelastic methods together with the "scattered light" method.

Milton M. Leven, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 981, 982, 1015, 1061, 1069)

1022. Bye, N. C., Elements of circular saw design, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51-A-120, 10 pp., 4 figs.

Purpose of paper is to bring out some of the principles which influence the behavior of a circular saw under operating conditions and to attempt to set up tentative mathematical formulas which might be useful in establishing the limits of operating possibilities or in evaluating the conditions which have to be met for successful operation.

From author's summary

1023. Sherman, D. I., On stresses in a twisted bar, weakened by a prismatic cavity (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 969–995, July 1951.

Paper deals with stresses and deformations of hollow bars subjected to twisting, particularly with the case of a circular bar with a rectangular cavity having rounded corners. Using the complex variable approach, the torsion function for particular outer and inner boundaries is determined by introducing an auxiliary function which leads to an integral equation solution. For the case considered, an approximate solution is obtained by replacing the integral equation by a system of linear algebraic equations. Paper includes solution of a numerical example.

It is interesting to note that shear stress on the outer boundary in the region of the corners of the cavity can be very closely approximated by shear stress in a hollow circular bar with circular cavity, the radius of which is taken as semidiagonal of the rectangular cavity. This approximation provides a simple method for determining maximum shear stress for design purposes.

B. Bresler, USA

1024. Abramyan, B. L., Torsion and bending of prismatic rods of hollow rectangular section, *NACA TM* 1319, 24 pp., Nov. 1951.

See AMR 4, Rev. 2408.

1025. Markland, E., The deflection of a cable due to a single point load, *Phil. Mag.* (7) **42,** 332, 990–996, Sept. 1951.

Paper gives a method for the calculation of influence coefficients for vertical loads and deflections of a uniform cable. These coefficients, which are functions of the applied load, are required for the analysis of suspension bridges after the manner of A. G. Pugsley [*J. Inst. civ. Engrs.* **32,** p. 226; *Struct. Engr.* **27,** p. 327]. Experiments on a 5-ft chain agree very well with the calculations.

W. S. Hemp, England

1026. Tyler, C. M., Jr., and Christiano, J. G., Analysis of straight and curved beam-columns, *J. appl. Mech.* **18,** 3, 283–284, Sept. 1951.

Relaxation method is employed to analyze members having both axial and transverse loading in the form of beam-column. Member is divided into a number of segments, and value of the bending moment is found directly. Method is applicable to sections of any shape and stiffness. Example of an irregularly shaped beam-column is worked out.

S. K. Ghaswala, India

1027. Dewulf, N., Assay of calculation of gain, from the viewpoint of buckling, resulting from flexible hooping of pressure pipes (in French), *Génie civ.* **78,** 15, 287–290, Aug. 1951.

First, the buckling of a pipe without hooping is discussed using the energy method, the shape of the pipe after buckling being given by $r = r_0(1 + a\cos 2\varphi)$, r_0 and a being constant. If $a = 0$ and the tangential pressure stress is given by t_0, the potential energy of the longitudinal forces is $\phi_0 = t_0^2 e\, 2\pi r_0/2E$, e being the thickness of the wall and E the modulus of elasticity. If $a \neq 0$, the circumference is $S = 2\pi r_0(1 + a^2)$, the corresponding pressure stress $t = t_0 - E(S - 2\pi r_0)/2\pi r_0 = t_0 - Ea^2$, and the corresponding potential energy $\phi_1 = t^2 eS/2E - \phi_0$. The potential energy of bending moments is $\phi_2 = 9\pi a^2 EJ/2r_0$, J being the moment of inertia. $\phi_1 + \phi_2$ is the total potential energy. The work of external forces is $T_v = -p\int_0^{2\pi}\int_{r_0}^{r} r\,d\varphi\,dr = -pr_0^2\cdot\pi a^2/2$. The total potential energy is then $\theta = \phi - T_v$. From $d^2\theta/da^2 = 0$ follows, with $t_0 e = pr_0$, the equation of the external critical pressure: $9EJ/r_0^3 - 3p + 2\,et_0^2/Er_0 = 0$.

In the case of hooping it is assumed that the shape of the pipe after buckling is the same as without hooping. This assumption is not valid since, because of the supposed shape of the buckled pipe, the normal pressure in the case of hooping must vary with φ and, therefore, must have another shape from that without hooping. First, author discusses case when the hoops can glide infinitely well, only abnormal small tangential stresses being possible. Supposing the same as above (the stress of the hoops is $T = T_0 + E_1 a^2$, E_1 the modulus of elasticity of hoop), one finds now $9EJ/r_0^2 - 3pr_0 + 2(et_0^2/E + e_1 T_0^2/E_1) = 0$, the bracket not being negligible, since t_0 and T_0 are of the same order as the stresses t_v and T_v, which appear when the critical external pressure is diminished to zero. An example given by the author results in an increase of the critical pressure of 14% by hooping. In the normal case, when the hoops can slide, the stress of the hoops is $T = T_0 + E_1(ds_1 - ds_{10})/ds_{10}$, where ds_1 is the line element of hoop and ds_{10} its value for $a = 0$. For T, one finds a value varying with $\sin 2\varphi$, when one considers only the members of second order in a; then the part $e_1\int_0^{2\pi}(T^2/2E_1)ds_1$ of the potential energy is computed. The same method as in the case without hooping leads author to an equation for critical pressure, on the left side differing from the case without gliding by the additional

term $-3ne_1T_0^2/r_0T_1 + 6[3n^2/(r_0 + n) - n]e_1T_0/r_0 + 9n^2E_1e_1/r_0(r + n)$. Here n is the distance of the center line of pipe and hoop. In the example discussed, a gain of 62% results for the critical, external pressure. Comparison with experiment will be given later. H. Schlechtweg, Germany

1028. Holt, Marshall, A procedure for determining the allowable out-of-roundness for vessels under external pressure, Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51–A-136, 7 pp., 3 figs.

For inclusion in ASME Boiler Construction Code rules governing design of vessels under external pressure, author proposes determining allowable out-of-roundness of cylinder by single formula and chart, with second chart defining arc or chord over which deviation from circularity is to be measured.

Formula is based on analysis by R. G. Sturm [*Univ. Ill. Bull.* 39, 12, Nov. 1941] and paper contains nothing new from a theoretical standpoint. In adapting it to Code use, surprising simplicity of procedure has been achieved considering proposed application to vessels of wide range of diameters, lengths, and thicknesses, constructed of any of the ferrous or nonferrous materials covered by Code, and operated at any temperature for which Code assigns allowable stresses. Unavoidably, theoretical accuracy has been sacrificed to achieve this end, but assumptions are such that safety factors of the same order as used in design for internal pressure may be expected to result.

A. R. C. Markl, USA

1029. Conway, H. D., Chow, L., and Morgan, G. W., Analysis of deep beams, *J. appl. Mech.* **18,** 2, 163–172, June 1951.

For deep beams of rectangular cross section, authors present a solution of Airy's equation in Fourier series form on which a polynomial is superimposed to satisfy conditions of free boundary at ends. Coefficients of latter function are determined by least work, following Goodier. Comparison is made with finite difference solution and ordinary beam theory for special cases of length-depth ratios of 1 and 2. Method for exact solution is suggested, using a second trigonometric series.

Frank J. McCormick, USA

Plates, Disks, Shells, Membranes

(See also Revs. 1016, 1017, 1028, 1039, 1040, 1041, 1052, 1060, 1063)

1030. Paschoud, J., Numerical calculation of the circular deflection of plates of revolution with variable thickness (in French), *Schweiz. Arch.* **17,** 10, 305–312, Oct. 1951.

The circular bending of a plate of revolution with variable thickness is discussed by assuming a state of generalized plane stress in every section of the plate. Numerical results are obtained by a method of successive approximation. The accuracy obtained in a numerical example whose exact solution has been worked out by Henri Favre [*Bull. tech. Suisse Rom.* nos. 18, 19, 26, 27, 1949] suggests that the method can be profitably used for rapid calculations in practical applications.

B. R. Seth, India

1031. Tsurkov, I. S., Elastic stressed state of an arbitrarily loaded closed cylindrical shell (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 2, 169–193, Feb. 1951.

Starting with theory proposed by Vlasov, and using method of initial parameters, solution is given of differential equations pertaining to displacements u, v, w, of closed cylindrical shells subjected to arbitrary loading. From these solutions, shearing and normal forces and bending moments are obtained. One-time inadequacy of methods used by Vlasov and others is removed and meaning of differential equations for flat (slightly curved) shells shown. Procedure is shown in detail but no concrete case is discussed. A condensed version of author's conclusions follows:

(1) Fundamental system of symmetrically constructed differential equations for cylindrical shell pertaining to displacements u, v, w, expressed by single trigonometric series for the n-member of series reduces to solution of determining ordinary differential equation of eighth order. (2) Roots of characteristic equation obtained from determining differential equation show that for all $n \geqq 2$ and radius to thickness ratio $\geqq 100$, theory of flat shells can be used. (3) Problem of calculating shells corresponding to members of series $n = 0$ and $n = 1$, for which theory of flat shells does not apply, is obtained with ease; $n = 0$ implies axial symmetry and $n = 1$ implies bending of shell as a beam. (4) Simplifications allow use of method of initial parameters for all members of series. (5) Solution of homogeneous problem is presented as a matrix; for $n = 0$, matrix contains 16 functions of influence of which, due to symmetry, only 10 are different from each other; for $n > 0$, matrix contains 64 functions of influence of which, because of symmetry, only 36 are different from each other. (6) To matrix of homogeneous problem automatically are added functions of influence due to external loadings; in this way, finding of particular integrals presents no difficulty. (7) Representation of general integral of the determining equation with initial parameters allows simplification not only in finding particular integrals but makes finding of arbitrary constants significantly easier; in the most general case of external loading it reduces problem of finding eight arbitrary constants to four. (8) Proposed method of calculations for strength of closed cylindrical shell is entirely practical and represents generalization of known work of A. N. Kryloff relating to beams on elastic foundations. Method can be used to design pipes fully or partially filled with water.

S. Sergev, USA

1032. Taylor, V. C., Stress and deflection tests of steam-turbine diaphragm, *Trans. ASME* **73,** 7, 877–886, Oct. 1951.

Results are given of static tests with a turbine diaphragm consisting of a semicircular ring of rectangular cross section (with nozzle vanes). Comparison is made with the results of elementary theory of curved bars.

In reviewer's opinion, however, an "equivalent" moment of inertia of the cross section should have been used in the analysis to allow for the influence of the nozzle vanes.

Heinz Parkus, USA

1033. Szabó, I., The axisymmetrically loaded thick circular plate, elastically supported (in German), *Ing. Arch.* **19,** 2, 128–142, 1951.

Author considers the problem of the loaded circular plate on an elastic foundation, when the ratio of the thickness and the radius is not small, while the load of the plate is an arbitrary function of the radius.

The starting point for the solution is the set of the well-known differential equations for the axially symmetric stress-and-strain distributions. The boundary conditions in the contact plane of plate and elastic foundations are $\zeta_{fo} = \zeta_{pl}$, $\tau_{pl} = 0$; $|r| \leq a$; $\tau_{fo} = 0$, for all r; $\sigma_{fo} = \sigma_{pl}$ for $|r| \leq a$; $\sigma_{fo} = 0$ for $|r| > a$; $a =$ outer radius plate; ζ_{pl}, ζ_{fo} are the axial displacement of a point in the contact plane of plate and foundation, respectively. A solution which satisfies all the boundary conditions, except $\sigma_\rho = 0$ for $r = a$, is constructed by the method of separation of the variables. By using the principle of Saint-Venant, author eliminates the difficulty of the nonsatisfied boundary condition by the

method of superposition. The constants of integration are to be found from an infinite set of linear equations. The existence of a solution is shown and approximating formulas for the unknowns are derived. A numerical example is given.

This treatment is important for the calculation of foundation plates. J. W. Cohen, Holland

1034. Pucher, A., Influence fields of elastic plates [Einflussfelder elastischer Platten], Wien, Springer-Verlag, 1951, viii + 13 pp., 52 tables, 10 figs. DM 27.70.

Author extends the one-dimensional influence-line method to plates where it becomes an influence field. The pertinent theory is presented briefly and several examples are worked out to guide the reader in the use of the 52 influence fields contained in the book. The influence fields are in the form of graphs and permit the determination of the moments and forms in plates. A method is indicated which is to be used for extensions to cases not covered specifically in the text. Harry H. Hilton, USA

1035. Benscoter, S. U., Secondary stresses in thin-walled beams with closed cross sections, *NACA TN* 2529, 104 pp., Oct. 1951.

Membrane theory of noncircular cylindrical shells whose cross sections are constrained to act as rigid laminas, while offering no resistance to warping, was studied originally in connection with deviations from elementary torsion theory in root regions of airplane wings. T. von Kármán and W. Z. Chien developed theory of nonuniform torsion of semi-infinite cylindrical shells of this type. Recently, further development of the problem has been stimulated by difficult stress problems raised by the delta wing.

In first part of report, author generalizes theory of von Kármán and Chien to include effects of bending and boundary conditions for cylinders of finite length. Second part extends theory to cylindrical shells with stringers and spars. Axial loads are assumed to be carried entirely by stringers and spar flanges (augmented by effective widths of sheet), while shear loads are carried entirely by skin and webs. Shear flow in any panel is assumed to be constant. Theory runs parallel to that in first part of report, with finite differences replacing differentials. Principles of the calculus of finite differences are used to advantage, but, in the end, numerical procedures must be used to solve difference equations.

Author is to be commended for comprehensive and rigorous treatment of a difficult problem that has attracted attention of leading aircraft stress analysts. H. L. Langhaar, USA

Buckling Problems

(See also Revs. 1027, 1064)

1036. Gerard, G., and Becker, H., Column behavior under conditions of compressive stress wave propagation, *J. appl. Phys.* **22, 10, p. 1298, Oct. 1951.**

The distance on slender bar that stress must be transmitted before buckling wave can form is derived neglecting inertia. This is equal to static Euler critical length, $L_{cr} = 2\pi (EI/P)^{1/2}$. Test of $^1/_2$-in. $\times$ $^1/_{100}$-in. bar checks calculations with $^1/_4$-in. wave length. C. M. Tyler, Jr., USA

1037. Bleich, F., Buckling strength of metal structures, New York, McGraw-Hill Book Co., Jan. 1952, xiii + 508 pp. $10.

This latest addition to the Engineering Societies Monographs Series is the most comprehensive treatise on structural stability problems since the publication of Timoshenko's "Theory of elastic stability" in 1936. It is intended for classroom or self-study by advanced students and research workers, and also for use by practicing engineers engaged in actual design of engineering and naval structures. Thus the scope is limited to the buckling of columns and beams, the stability of frameworks, and the strength of reinforced and unreinforced rectangular plates. However, the various topics are discussed in great detail and information is brought up to date. This book is also of interest to aeronautical structural engineers, although special problems, such as theory of tension field beams and buckling of curved plates and cylindrical shells are not included.

Book is very well written. Each chapter begins with an introduction containing a comprehensive historical survey of literature of the particular subject. The rest of the chapter then presents, in detail, the methods which occurred to the author to be the most important in practical application. On various occasions, author also introduces his original works on the simplification of available theories to make them practically useful by providing tables or approximate formulas, and also on the extension of theories of elastic buckling into the inelastic range. Author also provides additional references on various subject matters at the end of each chapter.

Chapter I starts with the "Buckling of centrally or eccentrically loaded columns," in which both the elastic and the inelastic theories are discussed. Chapter II introduces the general "Mathematical treatment of stability problems and the stability criteria" which includes a review of calculus of variation and characteristic value problem, a discussion of the energy method, and illustrations of the solution of buckling problem by successive approximation and by finite differences. Chapters III and IV deal with "Buckling of centrally loaded columns by torsion and flexure" and "Latera. uckling of beams." Chapters V, VI, and VII cover stabilities of built-up column and of frameworks; Chapter VIII deals with stability of elastically supported column. Chapter IX, which is entitled "Local buckling of plate elements of column," consists, essentially, of the problem of buckling of rectangular plates under uniformly distributed compressive loading on two opposite edges. Here, of the various theories of plastic buckling of plates proposed in recent years, only the stability theories of Ilyushin and Stowell are discussed in detail. Chapter X discusses the problem of "Rectangular plates with longitudinal stiffeners"; Chapter XI, the "Stability of web plates of girders." The last chapter deals with several "Special problems in the design of ship plating," including the buckling of continuous and restrained plates, the stiffening effects of lapped joints, and the ultimate strength of plate under compressive and normal loading.

Reviewer recommends this book as a useful reference for structural engineers. T. H. H. Pian, USA

1038. Biggs, J. M., The design of eccentrically loaded steel columns, *J. Boston Soc. civ. Engrs.* **38, 4, 333–356, Oct. 1951.**

Author discusses the present state of knowledge of the behavior of eccentric columns with relation to various building codes. Specifically, the advantages and disadvantages, as well as the theoretical limitations of the column requirements of the AISC, AREA, ASSHO, and Boston City Building Codes are pointed out. No new concepts are advanced but the need is indicated for further theoretical and experimental work in the eccentric column field. John Morley English, USA

1039. Klitchieff, J. M., Buckling of a triangular plate by shearing forces, *Quart. J. Mech. appl. Math.* **4, part 3, 257–259, Sept. 1951.**

Employing a double Fourier series for the deflection function of the middle surface of a right-angled isosceles triangular plate, simply supported along the edges and acted on by shearing forces uniformly distributed along the equal edges (each of length a) and

by normal forces of the same magnitude uniformly distributed along the hypotenuse, author obtains the approximate value of the critical shearing force as $46\pi^2D/a^2$, D being the flexural rigidity of the plate. Comparing this with the value $9.4\pi^2D/a^2$ for a square plate of side a [S. Timoshenko, "Elastic stability," New York, 1933, p. 360], author concludes that the value of the critical shearing force for a square plate is considerably increased when it is reinforced by a diagonal stiffener. There are a few misprints in this paper. D. N. Mitra, India

1040. Goodier, J. N., and Neou, I. M., The evaluation of theoretical critical compression in sandwich plates, *J. aero. Sci.* **18, 10, 649–656, 664, Oct. 1951.**

Buckling stresses obtained by various authors using different simplifying assumptions are compared with results of Goodier's rigorous theory ["Cylindrical buckling of sandwich plates," *J. appl. Mech.* **13,** 4, p. A-253, Dec. 1946] and with a simple plain strain theory corrected for the destabilizing effect of the compression in the core in accordance with suggestion of Williams, Leggett, and Hopkins ["Flat sandwich panel under compressive end loads," *Aero. Res. Counc. Lond. Rep. Mem.* no. 1987, June 1941]. In Euler-type buckling this corrected simple theory is in excellent agreement with rigorous theory, and correction is negligible when compressive load carried by core is less than 10% of compressive load carried by two faces. Correction is not needed in wrinkling and thus several earlier formulas are satisfactory. Practical significance of paper lies in evaluation of effects of simplifying assumptions. Evaluation by experiment is unsatisfactory because of large scatter of results in all sandwich testing. Presentation is simple and clear, and paper is most readable.

N. J. Hoff, USA

1041. Handelman, G. H., and Prager, W., Plastic buckling of a rectangular plate under edge thrusts, *NACA TN* **1530 =** *NACA Rep.* **946, 28 pp., 1949.**

Authors begin by discussing the advantages of a theory of plastic flow over one of plastic deformation, particularly with reference to desirable continuity of stress-strain relations in transition between loading and unloading. An explicit theory of the preferred type is developed and compared with other existing theories. Next, appropriate differential equations and boundary conditions governing the plastic buckling of a simply compressed plate are formulated. In particular, it is shown that here the plate must be considered as anisotropic, the anisotropy being a function of the compressive stress. As a first specific application, the plastic buckling of a narrow strip is investigated and the results are found to tend in the limit toward those contained in the Engesser-von Kármán theory of buckling of beams beyond the elastic limit, so long as the material is assumed to be incompressible. In the case of buckling of a simply supported rectangular plate, explicit results are again obtained and compared with the results of other theories. Torsional buckling of cruciform sections is considered as a third example. An energy method generalizing that relevant to elastic buckling is then presented, and its usefulness in obtaining approximate solutions is illustrated in the case of buckling of a cruciform section. A number of numerical results are presented in curve form.

Courtesy of Mathematical Reviews F. B. Hildebrand, USA

1042. Yoshimura, Y., On the mechanism of buckling of a circular cylindrical shell under axial compression (in Japanese), *Rep. Inst. Sci. Technol. Tokyo* **5,** 5, 179–198, Nov. 1951.

The lowering of the buckling load of a circular cylindrical shell is due to the nonlinear characteristic of finite displacement theory proposed by von Kármán and Tsien. Author develops further considerations about the essential features of the buckling phenomena. First of all, the fact that the buckled surface is very near to a developable one different from the original cylindrical surface, and therefore the deformation in this case is finite and approximately inextensional, is confirmed both theoretically and experimentally. Based upon this fact, the general and the local buckling with and without the loading spring being analyzed from the energy viewpoint, it is clarified that the buckling processes are all explained by the energy difference before and after buckling and the energy barrier to be jumped in this case. According to the results, local buckling is more liable to occur than general buckling, and in all cases the minimum load, above which the buckling can take place, exists, it being smaller in the case of local buckling than that of general buckling, and further depends on the rigidity of the spring of the former case. From author's summary

1043. Weidenhammer, F., Buckling of elliptical rings (in German), *ZAMM* **31,** 10, 329–331, Oct. 1951.

Author studies the buckling in its plane of an elliptical ring under a special nonuniform distribution of external forces, which produces uniform compression N in the entire ring. He states that this problem is of interest in mining, because such rings are now used as reinforcements and because the ratio of their axes is precisely chosen to avoid bending, as far as possible.

The critical value N_{cr} of the compression in the ring is obtained by integrating the differential equation deduced from the theory of curved beams. The external forces are assumed to change during the buckling process in such a way as to keep the compression force constant in all cross sections. The following results are obtained: b/a = 1.00, 1.10, 1.20, 1.35, 1.50, 1.65; $N_{cr}a^2/EI$ = 3.00, 2.70, 2.40, 2.00, 1.70, 1.45. In this table, a is the half minor axis, and b the half major axis of the ellipse. EI is the bending rigidity of the ring for flexure in its plane.

Ch. Massonnet, Belgium

1044. Dutheil, J., Fundamental problems of instability of metallic structures: Buckling and lateral instability (in French), *Ann. Inst. tech. Bât. Trav. publics* (*N.S.*) no. 218, 18 pp., Nov. 1951.

Author considers buckling as a problem of bending and derives Perry formula for struts based on concept of limiting stress, with, however, safety factor incorporated as a factor on the magnitude of the initial imperfections (lack of straightness). For lateral buckling in flexure, the beam is transformed into a fictitious beam of two flanges, having the same primary modulus of rigidity as the original. Lateral buckling is shown to be the equivalent of the behavior of these flanges as struts supported on an elastic foundation, the reactions of which are functions of the torsional and secondary flexural rigidities of the original beam. Practical solutions for a variety of problems, including results for battened columns, are given in terms of allowable stresses, and author compares results with Belgian and American practice.

Jacques Heyman, England

1045. Flint, A. R., The influence of restraints on the stability of beams, *Struct. Engr.* **29,** 9, 235–246, Sept. 1951.

The effects of beam end restraints in rotation in the plane of loading, in the lateral plane, and in torsion about the beam axis on the critical load of a beam are calculated separately by the application of the principle of minimum potential energy. Beams of uniform section under two equal loads applied symmetrically with respect to the mid-span are used in the investigation. Calculations of the effects of intermediate elastic restraint at mid-span against lateral bowing of a single beam and the effect of intermediate torsional restraint due to a filler joist rigidly attached to the webs of two adjacent beams on the critical load are

also made. The above different restraints affect critical load considerably, so they should be considered in the design of slender beams. Theoretical curves are shown with experimental checks.

T. H. Lin, USA

1046. Banerjee, S. P., Buckling of slender bearing piles and their design with reference to critical loads, *Civ. Engng. Lond.* **46,** 543, 672–674, Sept. 1951.

Author treats the problem of buckling of slender bearing piles as that of buckling of bars on elastic foundations. The classical solutions [e.g., Hetényi, M., "Beams on elastic foundation," Univ. of Michigan Press, 1946] are reviewed. Simple approximate equations are introduced for quick estimation of buckling load. Method is illustrated by examples concerning the design of reinforced-concrete piles which are to be used to bear on a hard stratum after penetrating soft soil. T. H. H. Pian, USA

1047. Schleicher, F., On the theory of plastic buckling (in German), *Bauingenieur* **26,** 5, 7; 139–141, 197–201; May, July 1951.

Review of elementary theory of plastic buckling of columns based, mainly, on Shanley's model, with some additional comments and calculations. Same topics have been treated more fully by Duberg and Wilder [AMR **4,** Rev. 1987].

P. S. Symonds, USA

Joints and Joining Methods

(See also Rev. 1055)

1048. Fahlbusch, H., Carrying capacity of bolts in timber constructions under static loads (in German), *Forsch. Geb. Ing.-Wes. B* **17,** 3, 83–93, 1951.

There are four possibilities of failure of bolted timber connections: (1) Failure in bearing by formation of wedge; (2) splitting if load is parallel to fiber; (3) shear failure; and (4) tensile failure in wall adjacent to hole if edge distance is too small. Connections are deemed to have failed if permanent deformation amounts to 2% of hole diameter, unless fracture occurs earlier. Standardized testing procedures for determining bearing strength have been developed. Empirical formulas are proposed for bearing strength as function of compressive strength in different directions to fiber. Experimental data for many types of natural and manufactured timbers are given.

Limiting conditions for different types of failure are derived, and failing loads for short and long bolts are given. Bolted connections with more than one bolt are discussed.

R. Weck, England

1049. Privoznik, L. J., Residual stresses in welded mild-steel pipe, *Weld. Res. Suppl.* **16,** 9, 422s–428s, Sept. 1951.

Sachs's boring-out method is used to determine the residual stress in circumferential welds in $5^1/_2$-in. OD $^1/_2$-in. thick steel pipe.

In the as-received pipe welded without preheat or stress relief, high tensile stresses (30,000 psi) at the inner surface of the pipe were found which decreased in a nearly linear manner to compressive stresses of about the same magnitude near the outer surface. The circumferential stresses were small (maximum of the order of 5000 psi), being compressive near the inner surface and tensile near the outer surface of the pipe. In weld made after pipe was annealed, maximum transverse stress was about 100,000 psi and circumferential stress was higher than in the as-received pipe. Residual stress in the as-received pipe had a maximum of 25,000 psi and a somewhat different distribution.

Results can be explained qualitatively by considering a band shrunk around the pipe which would set up a bending moment in the pipe wall to produce transverse tensile stresses at the inner surface and transverse compressive stresses at the outer surface.

Author contends that high transverse tensile stresses at inner surface would be beneficial and aid in carrying internal pressure loads. This does not seem to be correct, since the tensile residual stress would add to the tensile axial stress due to pressure, with an increased tendency to open up defects in the weld.

W. O. Richmond, Canada

1050. Hartbower, C. E., and Pellini, W. S., Investigation of factors which determine the performance of weldments, *Weld. Res. Suppl.* **16,** 10, 499s–511s, Oct. 1951.

Paper describes application of explosion bulge technique to study the fracture performance of prime plate and butt weldments in $^3/_4$-in. thick high-tensile steel and mild-steel plates. Welds were made with E12016, E7016, and E6010 electrodes. Deformation characteristics of the various weld and base metal combinations were investigated, together with their flow strengths and Charpy V-notch transitions, in an attempt to determine the basic factors controlling weld performance.

The notch toughness and flow strength of the weld metal, rather than the heat-affected metal, appear to be the major controlling factors in determining the performance of pearlitic steel weldments.

Authors found the performance of the E12016 weldments, both in high-tensile and in mild steel, to be essentially equal to the performance of the prime plates, the transition from ductile to brittle behavior occurring at −105 F. The E7016-HTS weldment performance was inferior to that of the prime plate, the transition range being −50 to −75 F. The E6010-HTS weldment was decidedly inferior in performance to the E7016-HTS weldment, its transition range being 0 to −75 F. The E6010-MS performance (transition range −50 to −75 F) was superior to E6010-HTS and approximately equal to E7016-HTS.

F. J. Winsor, USA

1051. Crawford, A. E., Ultrasonic soldering of light metals, *Metallurgia, Manchr.* **44,** 263, 113–116, 121, Sept. 1951.

The refractory nature of the oxide film present on the surface of aluminum and its alloys requires very active fluxes in soft soldering by normal methods, and this, in turn, gives rise to corrosion difficulties. Paper describes use of ultrasonics for the purpose of disrupting the oxide film in order to permit wetting of the surface by the solder. Advantages and limitations of method are discussed, and details are given of equipment available for its application. From author's summary by F. J. Winsor, USA

1052. Moszynski, W., The calculation of the resistance of flanged pipe joints (in Polish), *Arch. Mech. stos.* **3,** 1, 27–43, 1950.

Author considers two kinds of pipe joints, one with a loose flange subject to bending, and the other with a fixed flange. To calculate a loose flange, he establishes the formulas for a rectangular section and for a section of any shape. By these formulas one can determine the circumferential unit stresses σ at any point (x, y) of the section and their values σ_{max}, the influence of through-holes for flange bolts being disregarded. This calculation is based on the assumption that a section of the flange subject to bending turns round the center of gravity of its full surface without undergoing any deformation. However, the weakening of the flange by through-holes is taken into account in the final calculation of the maximum unit stress σ_{max}. For calculating a fixed flange, the following simplifications are introduced: A section of a flange subject to bending undergoes no deformation, but the

center of gravity of its full surface moves radially owing to the connection with the tube and to the internal pressure; moreover, if the thickness g_r of the wall of the tube increases in the vicinity of the flange up to g_s, a constant thickness $g = 0.7g_r + 0.3g_s$ of the wall is assumed. Consider the deformations of a narrow sector of the tube, regarding it as a beam connected with an elastic base and loaded on one end with a bending moment and a shearing load; the angles of rotation ψ_0 and ψ_k of the common section of the tube and of the flange, as well as the radial displacings of the center of its thickness u_r and u_k, are equal; the bending moment can, therefore, be determined. This enables us to calculate a reducing factor κ''. Consider now the bending of a substitute straight flange, having the same section as the annular flange dealt with above. To obtain the true values of the stresses appearing in an annular flange, we must multiply the stresses calculated for a straight flange by the factor κ''. Further, a similar factor κ' is calculated for a cylindrical section of the flange which corresponds to the external surface of the tube. Finally, two other factors κ_0'' and κ_0' are established for the case when there is no pressure inside the tube. As an example, 72 numerical values of these factors are calculated for 18 different relative sizes of tubes and flanges. The figures obtained show that all four factors vary within a very wide range and that κ_0' is always larger than κ', while κ_0'' is generally larger than κ''. For example, κ_0' varies from 0.896 for $D_n/g = 40$ and $g_k/g = 1$ to 0.375 for $D_n/g = 4$ and $g_k/g = 4$, where D_n is the internal diameter of the tube, g_k the thickness of the flange, and g as given above; for the same flanges κ_0'' varies from 0.820 (but $\kappa'' = 0.854$) to 0.078. The established formulas enable determining the values of the factors κ for all standard joints with fixed flanges, which will facilitate the calculations of their strength. K. Zarankiewicz, Poland

Structures

(See also Revs. 995, 1018, 1093)

1053. Seelye, E. E., Data book for civil engineers. Vol. I, Design; Vol. II, Specifications and cost. 2nd ed., New York, John Wiley & Sons, Inc., Dec. 1951, xlv + 658, xii + 505 pp. $10, $13.

Author has brought together in two volumes much information useful in design and construction of engineering works and buildings. Fundamentals and theory, for the most part, are not covered. Volume I contains commercial and graphic standards; design tables and charts for structural elements of steel, reinforced concrete, timber, and other materials; data on pavements, airports, water and sewerage works, and other construction; all these are useful in routine design. Volume II contains standard contract forms and specifications; cost data for use in estimating and appraisal of buildings, structures, and engineering works; data on power costs; and civil engineering glossary.

John E. Goldberg, USA

1054. Da Silva Júnior, J. F., Simplification of the Cross method for the calculation of flexible structures (in Portuguese), *Inst. Pesq. Technol. São Paulo Publ.* no. 435, 18 pp., 1951.

Purpose of this paper is to explain a method which can be considered as one of the most advanced forms of the simplifications of the Cross method. It is possible thus to avoid the resolution of the system of n linear equations (if n is the number of independent translations), and therefore to realize the $n + 1$ compensations.

The principles of the method are: (1) The joints are assumed to be fixed against rotation, and the structure restrained against sidewise movements. Moments on the two fixed-end beams are calculated. (2) The unbalanced fixed-end moments of the joints are distributed among the connecting members in proportion to their stiffness. (3) Relations between end moments and between relative displacements of the ends of the members are found and combined into one expression: $\Sigma M = C$. (4) The moments resulting from distributing the unbalanced fixed-end moments of the joints will not satisfy generally the relations which have been previously determined. Then it is necessary to introduce moments for compensating these differences. (5) The carry-over moments are added to the "compensating" moments, and both of them are then distributed as in the first step.

This process is repeated until the necessary corrections and carry-over moments are small enough to be neglected. The illustrations include numerous examples of the application of the method to different types of structures.

Reviewer believes that the basic idea of the method is to introduce the moments produced by the relative displacements of the ends of the members as unknowns which are computed by the iterative process in the same way as the other unknowns (statical moments produced by the rotations of the joints). At every step of the successive corrections of the joints the condition of statical equilibrium $\Sigma M = 0$ is used, and the unbalanced moments are distributed proportionally to the stiffness of the members. In a similar way, author applies at every step the condition of transversal equilibrium $\Sigma M = C$, and distributes the "unbalanced moment" among the members proportionally to their contribution to the transversal stiffness of the structure. This idea of applying the same process to the unknowns derived from the displacements of the joints, as employed to the other unknowns, is usual in those methods which use deformations as unknown quantities (slope-deflection methods). [See *Cienc. y Técn.* **108,** p. 538 and following, 1947.]

Hence, although similar methods of successive corrections of artificial joint restraints have been used, the proposed method has the advantage of being much more simple and more general. Therefore this modification seems to be useful for those engineers who prefer the Cross method.

Cesar Augusto Sciammarella, Argentina

1055. Lothers, J. E., Elastic restraint equations for semi-rigid connections, *Amer. Soc. civ. Engrs. Proc.* Separate no. 5, Feb. 1950 = *Trans. Amer. Soc. civ. Engrs.* **116,** 480–494, 1951.

Author develops an analytical approach to evaluating rigidity of structural framing angle connections. Initial tangent values to $M - \phi$ curves are determined which check experimental results with good agreement. Designers of rigid structures may find Table I of considerable value. F. L. Castleman, Jr.

1056. Leonhardt, F., and Hoyden, A., Relations in ground-anchored suspension bridges as a means for their calculation (in German), *Bauingenieur* **26,** 8, 230–234, Aug. 1951.

Authors demonstrate that, for long-span suspension bridges, the criterion of rigidity, consisting in a limitation of the statical deflection η_{max} of the bridge to a certain ratio of the span (usually $1/700$), is irrational; the necessary condition to impose is that the minimum radius of curvature of the bridge floor under the heaviest concentrated loads is of sufficient magnitude to give no trouble to traffic. Authors propose for this minimum radius R different values according to the importance of the road supported by the bridge (e.g., 6000 ft for parkways). The radius R depends on 12 different factors, the most important of which are the following: (1) The span l; (2) the relative sag f/l of the cable; (3) the ratio g/p = dead load/live load; (4) the constant moment of inertia J of the stiffening girder.

Paper consists essentially in the presentation and detailed instructions for using 5 charts, corresponding, respectively, to the

also made. The above different restraints affect critical load considerably, so they should be considered in the design of slender beams. Theoretical curves are shown with experimental checks.

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The refractory nature of the oxide film present on the surface of aluminum and its alloys requires very active fluxes in soft soldering by normal methods, and this, in turn, gives rise to corrosion difficulties. Paper describes use of ultrasonics for the purpose of disrupting the oxide film in order to permit wetting of the surface by the solder. Advantages and limitations of method are discussed, and details are given of equipment available for its application. From author's summary by F. J. Winsor, USA

1052. Moszynski, W., The calculation of the resistance of flanged pipe joints (in Polish), *Arch. Mech. stos.* **3,** 1, 27–43, 1950.

Author considers two kinds of pipe joints, one with a loose flange subject to bending, and the other with a fixed flange. To calculate a loose flange, he establishes the formulas for a rectangular section and for a section of any shape. By these formulas one can determine the circumferential unit stresses σ at any point (x, y) of the section and their values σ_{max}, the influence of through-holes for flange bolts being disregarded. This calculation is based on the assumption that a section of the flange subject to bending turns round the center of gravity of its full surface without undergoing any deformation. However, the weakening of the flange by through-holes is taken into account in the final calculation of the maximum unit stress σ_{max}. For calculating a fixed flange, the following simplifications are introduced: A section of a flange subject to bending undergoes no deformation, but the

center of gravity of its full surface moves radially owing to the connection with the tube and to the internal pressure; moreover, if the thickness g_r of the wall of the tube increases in the vicinity of the flange up to g_s, a constant thickness $g = 0.7g_r + 0.3g_s$ of the wall is assumed. Consider the deformations of a narrow sector of the tube, regarding it as a beam connected with an elastic base and loaded on one end with a bending moment and a shearing load; the angles of rotation ψ_0 and ψ_k of the common section of the tube and of the flange, as well as the radial displacings of the center of its thickness u_r and u_k, are equal; the bending moment can, therefore, be determined. This enables us to calculate a reducing factor κ''. Consider now the bending of a substitute straight flange, having the same section as the annular flange dealt with above. To obtain the true values of the stresses appearing in an annular flange, we must multiply the stresses calculated for a straight flange by the factor κ''. Further, a similar factor κ' is calculated for a cylindrical section of the flange which corresponds to the external surface of the tube. Finally, two other factors κ_0'' and κ_0' are established for the case when there is no pressure inside the tube. As an example, 72 numerical values of these factors are calculated for 18 different relative sizes of tubes and flanges. The figures obtained show that all four factors vary within a very wide range and that κ_0' is always larger than κ', while κ_0'' is generally larger than κ''. For example, κ_0' varies from 0.896 for $D_a/g = 40$ and $g_k/g = 1$ to 0.375 for $D_a/g = 4$ and $g_k/g = 4$, where D_a is the internal diameter of the tube, g_k the thickness of the flange, and g as given above; for the same flanges κ_0'' varies from 0.820 (but $\kappa'' = 0.854$) to 0.078. The established formulas enable determining the values of the factors κ for all standard joints with fixed flanges, which will facilitate the calculations of their strength. K. Zarankiewicz, Poland

Structures

(See also Revs. 995, 1018, 1093)

1053. **Seelye, E. E., Data book for civil engineers. Vol. I, Design; Vol. II, Specifications and cost. 2nd ed.,** New York, John Wiley & Sons, Inc., Dec. 1951, xlv + 658, xii + 505 pp. $10, $13.

Author has brought together in two volumes much information useful in design and construction of engineering works and buildings. Fundamentals and theory, for the most part, are not covered. Volume I contains commercial and graphic standards; design tables and charts for structural elements of steel, reinforced concrete, timber, and other materials; data on pavements, airports, water and sewerage works, and other construction; all these are useful in routine design. Volume II contains standard contract forms and specifications; cost data for use in estimating and appraisal of buildings, structures, and engineering works; data on power costs; and civil engineering glossary.

John E. Goldberg, USA

1054. **Da Silva Júnior, J. F., Simplification of the Cross method for the calculation of flexible structures** (in Portuguese), *Inst. Pesq. Technol. São Paulo Publ.* no. 435, 18 pp., 1951.

Purpose of this paper is to explain a method which can be considered as one of the most advanced forms of the simplifications of the Cross method. It is possible thus to avoid the resolution of the system of n linear equations (if n is the number of independent translations), and therefore to realize the $n + 1$ compensations.

The principles of the method are: (1) The joints are assumed to be fixed against rotation, and the structure restrained against sidewise movements. Moments on the two fixed-end beams are calculated. (2) The unbalanced fixed-end moments of the joints are distributed among the connecting members in proportion to their stiffness. (3) Relations between end moments and between relative displacements of the ends of the members are found and combined into one expression: $\Sigma M = C$. (4) The moments resulting from distributing the unbalanced fixed-end moments of the joints will not satisfy generally the relations which have been previously determined. Then it is necessary to introduce moments for compensating these differences. (5) The carry-over moments are added to the "compensating" moments, and both of them are then distributed as in the first step.

This process is repeated until the necessary corrections and carry-over moments are small enough to be neglected. The illustrations include numerous examples of the application of the method to different types of structures.

Reviewer believes that the basic idea of the method is to introduce the moments produced by the relative displacements of the ends of the members as unknowns which are computed by the iterative process in the same way as the other unknowns (statical moments produced by the rotations of the joints). At every step of the successive corrections of the joints the condition of statical equilibrium $\Sigma M = 0$ is used, and the unbalanced moments are distributed proportionally to the stiffness of the members. In a similar way, author applies at every step the condition of transversal equilibrium $\Sigma M = C$, and distributes the "unbalanced moment" among the members proportionally to their contribution to the transversal stiffness of the structure. This idea of applying the same process to the unknowns derived from the displacements of the joints, as employed to the other unknowns, is usual in those methods which use deformations as unknown quantities (slope-deflection methods). [See *Cienc. y Técn.* **108,** p. 538 and following, 1947.]

Hence, although similar methods of successive corrections of artificial joint restraints have been used, the proposed method has the advantage of being much more simple and more general. Therefore this modification seems to be useful for those engineers who prefer the Cross method.

Cesar Augusto Sciammarella, Argentina

1055. **Lothers, J. E., Elastic restraint equations for semi-rigid connections,** *Amer. Soc. civ. Engrs. Proc.* Separate no. 5, Feb. 1950 = *Trans. Amer. Soc. civ. Engrs.* **116,** 480–494, 1951.

Author develops an analytical approach to evaluating rigidity of structural framing angle connections. Initial tangent values to $M - \phi$ curves are determined which check experimental results with good agreement. Designers of rigid structures may find Table I of considerable value. F. L. Castleman, Jr.

1056. **Leonhardt, F., and Hoyden, A., Relations in ground-anchored suspension bridges as a means for their calculation** (in German), *Bauingenieur* **26,** 8, 230–234, Aug. 1951.

Authors demonstrate that, for long-span suspension bridges, the criterion of rigidity, consisting in a limitation of the statical deflection η_{max} of the bridge to a certain ratio of the span (usually $1/700$), is irrational; the necessary condition to impose is that the minimum radius of curvature of the bridge floor under the heaviest concentrated loads is of sufficient magnitude to give no trouble to traffic. Authors propose for this minimum radius R different values according to the importance of the road supported by the bridge (e.g., 6000 ft for parkways). The radius R depends on 12 different factors, the most important of which are the following: (1) The span l; (2) the relative sag f/l of the cable; (3) the ratio g/p = dead load/live load; (4) the constant moment of inertia J of the stiffening girder.

Paper consists essentially in the presentation and detailed instructions for using 5 charts, corresponding, respectively, to the

ratios $f/l = 1/9, 1/10, 1/11, 1/12$, and $1/13$. The charts were obtained by calculating many bridges having the principal dimensions of the suspension bridge over the Rhine at Köln-Mühlheim, Germany (main span 1050 ft; side spans $\cong {}^1/_4$ of the main span) and a continuous stiffening girder. The theory used was that of Klöppel and Lie [*Stahlbau* **14,** pp. 65 and 78, 1941]. The live loads were chosen according to the German specifications and the temperature range was of ±35 C.

Each Cartesian chart consists of four families of curves corresponding to a constant value of R and giving, respectively, the dead load g, the horizontal component of the force in the cable due to the live load $H_{p\,\max}$, the maximum moment in the stiffening girder $M_{\max}$, and the maximum deflection of this girder $\eta_{\max}$, all as functions of J.

In order to obtain the general dimensions of a new suspension bridge, one must first chose R and g; then, the chart gives J. J and R being known, the chart gives successively $H_{p\max}$, $M_{\max}$, and $\eta_{\max}$. Finally, from $M_{\max}$ and R, and for a chosen working stress in the steel, one deduces the height of the stiffening girder. A numerical example illustrating the procedure is discussed in detail. Authors show finally how the charts can be applied to bridges of other spans and other live loads, using the rules of mechanical similarity. Here also, a detailed numerical example is given. Ch. Massonnet, Belgium

1057. Whitney, Ch. S., Anderson, B. G., and Salvadori, M. G., Comprehensive numerical method for the analysis of earthquake resistant structures, *J. Amer. Concr. Inst.* **23,** 1, 5–28, Sept. 1951.

The analytical field of engineering seismology has been well served by publication of this paper devoted to an accurate step-by-step analysis of earthquake stresses in multistory frame buildings. Normal static load methods are being slowly replaced by dynamic load methods, due mainly to correct recognition of structural behavior during ground motion as a dynamic vibration phenomenon of transient nature. From a study of blast problems in structures, authors have evolved this procedure for the determination of shears due to earthquake oscillations in buildings.

Assumptions made are: (a) Mass of each floor is concentrated at corresponding floor level; (b) building oscillations are due to shear only, since deflections due to direct stress in columns assume importance only in structures having height-to-width ratio more than five; (c) shear of each story is only a function of elastic deflection between floors. This assumption is correct for a structure with pin connections in which lateral resistance is offered by diagonal bracing, or in continuous frame whose girders are of infinite stiffness. For all other conditions this assumption has to be modified to take into consideration the redistribution of moments due to rotation of joints. This analysis also takes into account effects of an elastic subsoil which allows the structure to rock under action of ground motion, while the condition of a highly rigid foundation which forces the structure to follow ground displacements without relative rotation or translation, is also presented as a special case. In an evenly spaced time of duration h seconds, it is shown that this analysis gives an error of the order of h^6 for all cases which ignore damping, and h^3 for cases where damping is taken into account, as against an error of the order of h^3 or h^4 at each step in the case of conventional dynamic load methods evolved so far.

Reviewer believes that, in spite of the accuracy of this method, it will fail to appeal to structural engineers not fully conversant with electric computers or I.B.M. punch-card machines, which form essential tools for the solution of differential equations encountered in this analysis. A more rational approach toward the analysis of earthquake forces has been given recently by Anderson and others and is worthy of close study [see "Lateral forces of earthquake and wind," *Proc. Amer. Soc. civ. Engrs.*, Separate no. 66, Apr. 1951, p. 38]. Their method involves the determination of the total lateral force or the base shear transmitted into the structure from the ground, and the distribution of that shear as equivalent forces applied to that structure.

The more rigorous method presented here needs encouragement and further experimental support to guide the thinking toward less rigorous but more practicable methods.

S. K. Ghaswala, India

1058. Rudelstorfer, K., The friction coefficient between the tire of a vehicle and the street surface (in German), *Z. Öst. Ing.-Archit.-Ver.* **96,** 17/18, 149–151, Sept. 1951.

Author emphasizes importance of road design. He presents functional dependence of maximum permissible speed on radius, transverse inclination, and coefficient of friction. Oerley's formula constitutes the mathematical background. A table summarizes data from thirteen authorities on different kinds of pavements under typical climatic conditions: dry, wet, and slippery. Practical constancy of friction coefficient is deduced for all kinds if dry pavement is used. Author regrets lack of experience on transverse friction with adequate speeds; he notes small corresponding friction coefficient and presents graphical translation of two of Oerley's functions. He proposes his own diagram in which dependence appears between coefficient of friction and speed; centrifugal force must be distributed within frictional reaction and inclination. Diagram and conclusions help to balance design elements: radius, inclination, and coefficient.

Reviewer notes the good reference sources, the correct and simple use of dynamical concepts, and the practical interest.

Jorge Carrizo Rueda, Argentina

1059. Abeles, P. W., Some new developments in prestressed concrete, *Struct. Engr.* **29,** 10, 259–278, Oct. 1951.

Bibliography is extensive; literary style is diffuse, and emphasis is laid upon use of precast, prestressed components in conjunction with ordinary concrete placed in situ. Author states that with ratio of 1:3, respectively, of these materials, cost in place of combination is between 11 and 12 shillings per cubic foot against 3 or 4 sh. for ordinary reinforced concrete. Under certain conditions the precast elements acting as forms effect a further saving. Ten of fourteen such partially prestressed bridges have already been built for the L.N.E.R., and their design is described. In reviewer's opinion, prestressed concrete, save in very special cases, is a material reserved—currently at least—for those localities possessing highly skilled, low-paid labor, and a shortage of materials. A. H. Finlay, Canada

1060. Wijnstra, G., Prestressed concrete pipes used for water supply lines (in Dutch), *Ingenieur* **63,** 27, 31; Bt.49–Bt.55, Bt.57–Bt.59; July, Aug. 1951.

Article deals with European and American methods of making and designing prestressed concrete pipe, listing most of the current prestressing methods. Some types of joints of European design are also given. Werner H. Gumpertz, USA

1061. Abeles, P. W., The ultimate resistance of prestressed concrete beams, *Concr. Constr. Engng.* **46,** 10, 295–303, Oct. 1951.

Author deals with load at failure; behavior at working load will be discussed in a later paper. Author recommends factor of safety of 2 for steel and 2.5 to 3 for concrete.

Pretensioning and posttensioning have to be considered separately. Pretensioned under-reinforced beams fail by fracture or excessive elongation of the wires occurring at cracks, followed by crushing of concrete. Large deflections give warning of impend-

ing failure. Failure in over-reinforced pretensioned beams occurs suddenly and depends on quality and shape of concrete.

In posttensioned beams with nonbonded wires, steel extends freely, acting as a tie. Failure always occurs due to crushing of concrete, and percentage of steel is of minor importance.

Author works out equations and tables for the various cases, making simplifying assumptions, and gives illustrative examples.

Andrew Brodsky, USA

1062. **Zick, L. P., Stresses in large horizontal cylindrical pressure vessels on two saddle supports,** *Weld. Res. Suppl.* **16,** 9, 435s–445s, Sept. 1951.

In horizontal cylindrical vessels supported on two saddles, determination of the stresses near the supports and, if necessary, an economical stiffening, is a difficult task. Use of the general theory of shells would be too complicated here and, therefore, author is content with an approximate analysis involving a certain empirical assumption to bring theory into agreement with test results. Paper gives formulas for the stresses in the vessel wall, in the ring stiffeners and the supports, which are desirable supplements to the existing code rules.

Pavel Kohn, Czechoslovakia

1063. **Watts, G. W., and Lang, H. A., The stresses in a pressure vessel with a flat head closure,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51–A–146, 22 pp., 5 figs.

Paper presents results of computations for determining the stresses in a cylindrical pressure vessel with a flat head closure. The accurate bending theory of shells is used to evaluate the local bending stresses in the neighborhood of the junction of the flat head and the cylindrical body. Tables show the magnitudes of the shear stress, the circumferential stress, and the axial stress as multiples of $pd/2t$. The locations where these stresses are critical are also determined. Curves are given showing the maximum stresses as functions of the diameter-thickness ratio of the shell and of the thickness ratio of head to shell body. The range of calculation includes most vessel sizes encountered in practice.

Tables of influence numbers for the cylinder and the flat head are presented. These tables can be utilized in problems in which other elastic structures are attached to either member. The paper includes a discussion of the mathematical procedure.

From authors' summary by Marshall Holt, USA

1064. **Tyler, C. M., Jr., and Walker, T. J., Lateral elastic instability of hat-section stringers,** *J. aero. Sci.* **18,** 9, p. 633, Sept. 1951.

Note in Reader's forum.

1065. **Tu, S. N., Stress analysis of cylindrical semi-monocoque structures** (in Chinese), *Engng. Reps. nat. Tsing Hua Univ.* 4, 2, 50–77, 1950.

Analysis of semi-monocoque cylindrical structures is made for (1) closely spaced rigid bulkheads, (2) rigid bulkheads, with definite spacing, and (3) elastic bulkheads at definite spacing. The rigid bulkhead is taken as being rigid only in its own plane. The displacement, the shear strain, and hence the shear flow at different points can be expressed in terms of the displacement of a reference point in the bulkhead plane, a rotation about this point, and the longitudinal displacement. From the stress-strain relations, the equilibrium conditions of the variation of stiffener load and the shear flows, the conditions that the shear flows balance the external forces and torsional moment, relations between the longitudinal displacements of different stiffeners are expressed as differential equations of second order. With end conditions of all stiffeners known, the longitudinal displacements and the stresses of different stiffeners are solved. For rigid bulkheads with definite spacing, the shear flow in a panel is taken as constant. With m bulkheads and n stiffeners, there are $n(m-1)$ shear flows in $n(m-1)$ panels. With 3 equilibrium conditions on every vertical section between two bulkheads, there are $3(m-1)$ equilibrium conditions. The principle of minimum energy is used to obtain the additional equations. By methods of the calculus of variations, the shear flows in different panels are solved. For elastic bulkheads, the shear flow in the neighboring panels and external loads at this particular bulkhead are taken as loads on this bulkhead, and the strain energy of the bulkhead is calculated accordingly. This strain energy of the different bulkheads is included in the minimum energy calculations. The above analysis can also be applied to structures with cut-out and torsional problems. Illustrative examples on cut-out and torsion are given for the above three types of bulkheads.

T. H. Lin, USA

1066. **Mehmel, A., Contribution to the analysis of foundations of high chimneys** (in German), *Bauingenieur* **26,** 10, 293–297, Oct. 1951.

Author divides foundation into three elements. He gives differential equation for plate of variable thickness. Outer plate element is divided in radial direction into λ segments. Difference quotients are substituted for differential quotients to obtain a system of three-termed equations. Author indicates boundary conditions for determining all constants and unknowns and gives results of three analyses for comparison. Reviewer believes article is too abbreviated to be of much help to the designer.

Robert B. B. Moorman, USA

1067. **Böttcher, F. E., Dynamic study of machine foundations** (in Spanish), *Cienc. y Técn.* **117,** 592, 169–186, Oct. 1951.

The two types of loading considered are (1) impact and (2) periodic, in which resonance of the foundation may lead to failure. For the first type, an equivalent static load is computed as the product of the weight, a coefficient of fatigue, and a dynamic coefficient. The latter is taken as the velocity of the weight at impact divided by the square root of the product of the acceleration of gravity and the static deflection of the foundation. The coefficient of fatigue is apparently an arbitrary coefficient, to which values of 2 and 3 are assigned in the examples presented.

For the second type of loading, the conventional analysis for transmitted force is presented. Numerical examples are given, and brief discussion of design practice is included.

Glenn Murphy, USA

1068. **Bontron, J., Stability of foundation blocks under the action of horizontal forces** (in French), *Ann. Ponts Chauss.* 121, 2, 167–198, Mar.-Apr. 1951.

A quite consistent method is presented for studying stability of large blocks sunk in the ground and subjected to overturning forces, based on limit equilibrium in surrounding soil according to Boussinesq. It is assumed that ultimate bearing capacity is not exceeded under most heavily loaded corner and that base plane does not slide relative to soil; elemental motion of block is rotation only. Block dimensions are determined for general case of infinitely long, partially submerged block with water level above soil level. Equations describing various possibilities of stability are derived and plotted with asymptotic limits and practical ranges of variation clearly indicated. Introduction of safety factor is discussed. Solution of three-dimensional case of block of finite length is not attempted, except to note that friction on transverse faces, known only as lower limit, will increase safety. Author states that theory is verified by scale-model tests, but insufficient data are given to judge this point. Theory is applied

to numerical example: piers for Wilson quay, port of Nantes.

Component parts of theory presented are all known principles, but particular application to title subject is believed to be a new and valuable contribution. Gordon P. Fisher, USA

1069. Vandeghen, A., and Alexandre, M., Torsion tests on box girders (in French), *Bull. Centre Étud. Constr. génie civ. Hyd. Fluviale* **5**, 241–276, 1951.

Paper deals with effect of cut-outs on stress distribution and torsional rigidity of closed sections used in the chassis and booms of railway cranes. Effects are determined experimentally by welding 10-mm steel plates to form model girders with 110-mm square cross section, 1000 mm long. Investigated are cases without cut-outs and with various cut-out arrangements such that the ratio of the cut-out to the plate width approximated the full scale boom. The girders were subjected to end torque, and rotations and strains were measured. Principal stresses and directions are calculated. Similar stress data are obtained on full scale boom. Maximum shearing stresses of the model and full scale booms are compared. Howard H. Dixon, USA

1070. Wilson, G., and Williams, G. M. J., Pavement bearing capacity computed by theory of layered systems, *Amer. Soc. civ. Engrs. Proc.* Separate no. 16, May 1950 = *Trans. Amer. Soc. civ. Engrs.* **116**, 750–766, 1951.

The method of determining bearing capacity of pavements is based on the application of theory of elasticity to a two-layer system developed by D. M. Burmister. Comparisons are made with methods developed by Glossop and Golder, Westergaard, and the C.B.R. method. In general, the results parallel those of Westergaard for concrete pavements. The assumptions are that both layers have the same density and are fully continuous at interface. Charts for various combinations of parameters used are given. No experimental verification is presented. This should be considered rather essential in view of the idealized assumptions necessary in a theoretical investigation.

Michael V. Smirnoff, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 969, 1090, 1096, 1109)

1071. Sokolovskiĭ, V. V., Theory of plasticity [Teoriya plastichnosti] 2nd ed., Moscow, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 396 pp.

This second edition of the book presents a thorough revision of both the contents and the development of the subject found in the first edition. The development of the subject is more deliberate and better organized. Familiar ideas of the theory of elasticity are more frequently used as an introduction to plastic behavior. On the whole, the book is now more readable.

The following new topics are discussed: Simple loading of bodies and connection between the theory of elastic-plastic deformations and the theory of plastic flow; unloading in the theory of elastic-plastic deformations; trigonometric representation of the compounds of stress and strain, torsion of conical bars with nonlinear hardening; new methods of solutions of the plane strain problem; a new analogy for the plane elastic-plastic problem; plane strain state for a generalized stress-strain law; plane equilibrium of a plastic wedge under variable load; plane and axially symmetric equilibrium of a plastic mass between rigid walls; uniform rotation of a disk and bending of a round plate with nonlinear hardening.

However, the improvements over the first edition are offset by a number of serious disadvantages. The important developments of the mathematical theory of plasticity outside the USSR during the last three years are largely neglected. For example, the work of Hill and Lee in England, and of Prager, Drucker, and Greenberg in this country is not mentioned. Among the most important omissions, the following should be mentioned: (1) Discussion of the inherent difference between finite and incremental stress-strain laws and realization of the fact that finite laws violate certain physical requirements. (2) Realization of the fact that most practical boundary-value problems are of mixed character involving surface stresses and surface displacements. Accordingly, the emphasis on statically determinate problems does not seem justified, as was shown by the work of Hill and Lee. (3) Discussion of discontinuous stress and velocity fields which often represent the only admissible solution and have also proved useful for approximation purposes. (More recently, such fields have been used successfully in the construction of bounds for the safety factor; since much of this work is not yet published in other than mimeographed reports, however, the author cannot be blamed for ignoring this angle.)

The chapter headings are as follows: (I) Theories of plasticity; (II) Fundamental equations of plastic equilibrium; (III) Simple problems of elastic-plastic equilibrium; (IV) Plastic torsion of rods; (V) Plane plastic state; (VI) Stress distribution in plastic zones surrounding holes; (VII) Indentation of a plastic body; (VIII) Compression and extrusion of a plastic sheet; (IX) Plane stress state; (X) Plane strain state for a general law of plasticity; (XI) Plane equilibrium of a plastic wedge; (XII) Plane and axially symmetric equilibrium of a plastic mass between rigid walls; (XIII) Elastic-plastic bending of beams and plates; (XIV) Elastic-plastic bending of round plates and rings.

Courtesy of Mathematical Reviews H. I. Ansoff, USA

1072. Krieger, I. M., and Maron, S. H., Rheology of synthetic latex. I. Test of some flow equations, *J. Colloid Sci.* 6, 6, 528–538, Dec. 1951.

Measurements made with both concentric cylinder and capillary viscometers are in close agreement and show that type III synthetic latex is Newtonian at concentrations below about 25% solids, and non-Newtonian above. Analysis of the data demonstrates the absence of either a yield point at low shearing stresses or a limiting viscosity at high, ruling out Bingham body behavior. The linearity of logarithmic plots of the data indicates the applicability of the exponential flow equation of Farrow, Lowe, and Neale for the conversion of experimental observables to rate of shear-shearing stress values. However, above about 45% solids, separate exponential flow equations must be used at high and low shearing stresses.

From authors' summary by Melvin Mooney, USA

1073. Hasiguti, R. R., and Owadano, T., Formula for creep curves of metals, *Nature* **168**, 4277, p. 706, Oct. 1951.

Authors obtain from experiments the time-strain relation: $s = a - 1/(bt + c) + kt$, where s is resolved shear strain at the time t for single crystals, or logarithm of the ratio of the length of specimen at time t to initial length for polycrystalline materials.

Full details will be published later. Ed.

1074. Betteridge, W., and Franklin, A. W., An investigation of the structural changes accompanying creep in a tin-antimony alloy, *J. Inst. Metals* **80**, 147–150, 1951–1952.

It is rather well known that the creep deformation of metals is due to at least two different mechanisms, namely (1) nonviscous flow at the grain boundaries, (2) slip or deformation within the grains. It is also recognized that the two different mechanisms influence each other. This paper, using tin-5%-antimony alloy as the experimental alloy, not only confirms the existence of these

two mechanisms but also supplies further information on the nature of the mutual influence of the one mechanism on the other.

Microscopic studies reveal that movement in grain boundaries often causes high localized strains within the grain usually in line with the direction of the movement of the grain boundary. It is also shown that the slip bands and local strains within the grains produce cell-like mosaic structure within the grains. It is suggested that the "cell structure" observed by x-ray examination of creep specimens is a consequence of this breakup of the grains.

Yoh-Han Pao, USA

1075. **Oldroyd, J. G., The motion of an elastico-viscous liquid contained between coaxial cylinders. I,** *Quart. J. Mech. appl. Math.* **4,** part 3, 271–282, Sept. 1951.

The theory of periodic and steady states of motion of a liquid in a narrow gap between long vertical coaxial cylinders is considered, when the viscous and elastic properties of the material at small rates of shear are measured by three constants: a viscosity coefficient and two relaxation times. When the outer cylinder undergoes forced harmonic angular oscillations about its axis, and the inner cylinder is constrained by a torsion wire, the amplitude of uniform oscillation attained by the inner cylinder is calculated to give quantitative interpretation of observations made in different liquids.

From author's summary by F. Schultz-Grunow, Germany

1076. **Feltham, P., High-temperature rheology of metals,** *Metal Treatm.* **18,** 72, 389–394, Sept. 1951.

Mechanical methods of testing metals have developed historically from the need of the engineer for guidance as to metal resistance to deformation and fracture in structural applications. The high prestige gained by these methods through their technological adequacy strongly influenced and defined thinking and the design of experiments in all subsequent research in this field. More exacting demands made on metals today, particularly in service at high temperatures, begin to show the need for a reassessment of the conventional approach and for a reorientation in research. Author develops this thesis with reference to past, current, and possible future work in the high-temperature rheology of metals, and shows that a study of research in its historical, social, and economic setting can contribute materially to its advance.

From author's summary by M. J. Manjoine, USA

1077. **Feltham, P., High-temperature rheology of metals,** *Metal Treatm.* **18,** 73, 455–459, Oct. 1951.

This is the second and final part of the article [see preceding review]. Some of the methods for studying plastic flow, other than mechanical tests, are reviewed. M. J. Manjoine, USA

1078. **Slezkin, N. A., Differential equations of the deformation process** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **80,** 4, 561–564, Oct. 1951.

Author contends that plastic behavior cannot be described satisfactorily by considering stress-strain relations only; one must also modify differential equations of motion. He selects, as chief factor to be considered, existence of "activated" particles especially affected by, and affecting macroscopic conditions. His modification consists in writing separate terms for activated and unactivated particles (with separate densities, velocities, and stress contributions) in macroscopic formulas for transport of mass, momentum, and energy. He does little with these equations beyond showing that they reduce to usual ones in absence of activated particles and mentioning that additional relations are needed to make the problem determinate. Reviewer finds the theory, at its present stage, too fragmentary to evaluate.

William Fuller Brown, Jr., USA

1079. **Garner, F. H., Nissan, A. H., and Wood, G. F., Thermodynamics and rheological behaviour of elasto-viscous systems under stress,** *Phil. Trans. roy. Soc. Lond.* (*A*) **243,** 858, 37–66, Sept. 1950.

Test materials consisted of aluminum and calcium soaps of naphthenic or fatty acids dissolved in hydrocarbon liquids with aid of peptizers. Experimental data are reported for three different tests: (a) High-pressure extrusion, or squirting, (b) shear between a cone and a hollow cylinder in relative rotation, (c) shear between parallel circular plates in relative rotation.

In (a), at low pressures, the jet, initially conical, emerges as a smooth film; but at pressures greater than a critical pressure, film breaks immediately into a spray. With Newtonian liquids, it is found that at the critical pressure the kinetic energy of the jet is proportional to the surface tension of the liquid and does not correlate with Reynolds number. Experimental data with soap solutions are, therefore, interpreted as measuring dynamic surface tension or, in these experiments, the rupture strength of squirted film. Strength of some soap solutions was 5 to 10 times that of simple liquids. Similar results were obtained also with a flat, diverging squirted film, in which the width of the film before rupture was measured.

In (b), space between rotating cone and stationary cylinder connects through ports with liquid reservoir outside the cylinder. In steady state, level of solution inside the cylinder is below level outside. This manometric difference is corrected for centrifugal force and another effect considered to be frictional loss. The net manometric difference measures a secondary rheological force which is interpreted in terms of free energy of the solution in state of continuous shear. Development of free energy is attributed to breakup of colloidal structures into individual soap molecules. Measurements at different temperatures permit analysis of the free energy into internal energy and entropy. Test data for 7% aluminum stearate in petrol indicate, by extrapolation, that free energy becomes zero at 32 C.

In (c), manometric tubes connected to ports in stationary plate indicate liquid pressure as function of radial distance from center of plate (Weissenberg effect). Experimental data are reported for one soap solution tested over range of plate separations and rotational speeds. With exceptions attributed to experimental difficulties under certain conditions, the observed pressures agree with a theory assuming an osmotic pressure resulting from difference in concentration of molecularly dispersed soap between highly sheared and stationary regions.

Reviewer notes that while systems studied undoubtedly possess free energy in state of continuous shear, authors' thermodynamic theory is incorrect in important details. There is no conceivable mechanism to justify authors' assumption that "surfaces of uniform shear acted as if they were semi-permeable membranes. . . ." Proof of error in the theory exists in authors' formula for hydrostatic pressure in method (c), which predicts increasing pressure with increasing radius. This is contrary to the experimental data, and apparent agreement was obtained only by rejecting data outside a limited radius range.

The experimental data seem valid and are the first published quantitative data in this new and difficult field.

Melvin Mooney, USA

1080. **Greenough, G. B., Macroscopic surface stresses produced by plastic deformation,** *J. Iron Steel Inst.* **169,** part 3, 235–241, Nov. 1951.

It is not possible to explain the residual lattice strains observed

in plastically extended polycrystalline aggregates, using x-ray diffraction methods, entirely in terms of Heyn intergranular stresses. This paper is concerned with the possibility that macroscopic (large-scale) stresses are also present, superposed on the Heyn stresses, in iron and mild-steel specimens. It is shown that there is a macroscopic compressive biaxial stress in the surface of the aggregate; the layer containing this stress is, in the specimens used, about two crystals (8×10^{-3} in.) deep. The whole of the transverse component of this stress system is confined to the surface layer and is determined; the longitudinal component may not be entirely confined to the surface layer, and only the difference between its value at the surface and in the interior is measured. From author's summary

1081. Pieruschka, E., Derivation of fundamental equations for the deformation of a viscoelastic medium and their application to wave propagation (in German), *Ing.-Arch.* **19,** 45, 271–281, 1951.

Author gives a Cartesian tensor analysis of the deformation of a viscoelastic medium. Wave propagation is discussed in Maxwell-Fromm and Hookean materials and in Newtonian fluids.

H. G. Hopkins, England

1082. Colonnetti, G., Elasto-plastic equilibrium during passage of time (in French), *C. R. Acad. Sci. Paris* **233,** 11, 12; 593–595, 644–646; Sept. 1951.

Proofs are given of some elementary theorems in elastoplasticity. The final theorem, that a body under internal stresses with no external tractions will not change its shape during relief of stress by creep, is, in reviewer's opinion, neither proved nor true. F. R. N. Nabarro, England

1083. Frank, F. C., Crystal dislocations. Elementary concepts and definitions, *Phil. Mag.* (7), **42,** 331, 809–819, Aug. 1951.

In recent years, development of theory of dislocations in crystals has introduced new terminology. Some terms which were adequately defined in simple cases become ambiguous in complicated situations. Paper collects and systematizes definitions of following terms: ideal crystal, good crystal, bad crystal, associated paths, Burgers circuit, crystal dislocation, Burgers vector, dislocation node, screw dislocation, edge dislocation, glide, climb, translation twins (intrinsic and extrinsic), imperfect dislocation, conformity plane, sessile dislocation, extended dislocation, twin dislocation, twinning dislocation. Geometrical and kinematic properties of these configurations are discussed.

F. R. N. Nabarro, England

1084. Gol'denblat, I. V., On the equations of equilibrium for a plastic medium (in Russian), *Prikl. Mat. Mekh.* **13,** 1, 113–114, 1949.

Author derives a stress-strain law from the assumption that the free energy is a function of the absolute temperature and the linear and quadratic invariants of the strain tensor. The resulting stress-strain law is of the deformation type. [Stress-strain laws of this type represent (nonlinear) elastic rather than plastic behavior.] W. Prager, USA

Failure, Mechanics of Solid State

(See also Revs. 973, 1086)

1085. McClintock, F. A., On the direction of fatigue cracks in polycrystalline ingot iron, Ann. Meeting ASME, Atlantic City, 1951. Paper no. 51-A-9, 3 pp. = *J. appl. Mech.* **19,** 1, 54–56, Mar. 1952.

The hypothesis that fatigue cracks progress on surfaces of high shear stress is checked. A statistical method of analysis is developed to predict the directions that cracks take on the surface of specimens tested in rotary bending. Theoretical predictions of the deviation of the cracks from the circumferential direction are compared with experimental results.

Elio D'Appolonia, USA

Material Test Techniques

(See also Revs. 1049, 1050, 1235)

1086. Bruckner, W. H., The micro-mechanism of fracture in the tension impact test, *Weld. Res. Suppl.* **16,** 9, 459s–469s, Sept. 1951.

Paper is an extension of previous work by author [see AMR 4, Rev. 2502] in which steels exhibiting lamellar carbides were studied. Present work focuses attention on similar steels, which have had the lamellar carbides removed by a spheroidizing heat treatment, and Armco iron.

Energy absorption-temperature and reduction of area-temperature curves for the materials are shown for each of the initial energy levels a material was subjected to.

The spheroidized steels are compared on the basis of these curves. Partial fracture tests, analyzed with the aid of photomicrographs, enable author to conclude that fracture initiates in the spheroidal carbides at the ferrite grain boundaries, and that later in the fracture process, carbides within the ferrite grain fail. No appreciable twinning was observed in these steels. It was noted that cleavage initiated at the ends of the microcracks in the carbides.

Armco iron exhibited a peak in its curves at the high-temperature end of the transition region. Hardness tests relate this to intense plastic strain-energy absorption by the tubular region surrounding the earlier failing central portion of the notch volume. Last part of paper is devoted to a detailed discussion on the correlation of twinning and cleavage fracture in Armco iron.

Julius Mikolwitz, USA

1087. Mosborg, R. J., Apparatus for low-temperature tension tests of metals, *ASTM Bull.* no. 177, 41–44, Oct. 1951.

An apparatus for static tensile testing of cylindrical notched or flat unnotched specimens at temperatures down to that of boiling nitrogen (−321 F) is described. Temperatures between −90 and −230 F are obtained by surrounding the specimen and adjacent fixtures in Freon 12. A coil is submerged in the Freon so that liquid nitrogen passing through the coil can be used to control the bath temperature. Nitrogen is used as the bath for tests at −321 F. Tests between this temperature and that at which Freon freezes (−230 F) are not attainable.

An extensometer is also described. Obviously this cannot be used on the notched bars. Specimen alignment is obtained primarily through the use of spherical seats.

E. J. Ripling, USA

1088. Bergqvist, B., Apparatus for recording the compressive stress-strain curve for thin material coupons at large strains, *Flygtekn. Försöksanst. Medd.* 39, 31 pp., 1951. Kr. 3.50.

An ingenious method is described for determining the compressive stress-strain curve for thin sheet metal for strains extending as far as 0.04. The method can be regarded as an improved version of Madden's method [*J. aero. Sci.*, 1946], in which a wide strip of the metal is held between lubricated solid guides with two windows for the placement of strain gages on the face of the sheet. The principal improvement over Madden's method is in the provision of a dynamometer for measuring the friction force be-

tween the guide plates and the specimen. The dynamometer consists of a pair of bars acting as supports of the guide plates and instrumented with wire strain gages to record the friction forces transmitted to the guide plates and their supports. The friction forces on aluminum-alloy specimens 2 mm in thickness remained of the order of 1% of the applied force up to strains of 0.01 and then rose rapidly to a figure of the order of 5% as the compressive strain was increased up to 0.04. The disturbing effect of buckling of the specimen between guides could be neglected for aluminum-alloy specimens with a thickness exceeding 1.5 mm. Strains were measured with Huggenberger extensometers and with wire-resistance strain gages of a special type developed at the author's laboratories, which measure strains up to 7%. Excellent agreement was obtained between the stress-strain curves at different locations on the specimen after correcting for friction, on the assumption that the friction force decreased linearly from zero at the top of the specimen to the measured value at the bottom.

The author makes no specific mention of Miller's method [*NACA TN* 1022, 1946] in which the friction force between the lubricated guides and a specimen with a thickness down to 0.3 mm is kept negligible throughout a compression test up to the yield strength by a careful adjustment of the spacing between these guides. Walter Ramberg, USA

1089. **Bergsman, E. B., Some recent observations in microhardness testing,** *ASTM Bull.* no. 176, 37–43, Sept. 1951.

The ocular screw micrometer used for measuring the indentation diameter was calibrated by means of a very exact grating. The influence of indentation speed, length of the indentation period, vibrations, preparation of the specimen and particularly of the load was investigated. Higher hardness number is obtained the smaller the load; e.g., 4 to 10% higher at a load of 25 g than at a load of 1000 g.

Erle I. Shobert, II, USA

1090. **Srivastava, A. M., Ultrasonic studies of Weimarn gels,** *J. acoust. Soc. Amer.* **23,** 5, 553–558, Sept. 1951.

Elastic moduli of Weimarn gels, including sulfates, carbonates, phosphates of barium, strontium, etc., are determined at different temperatures by an ultrasonic pulse method with frequencies of 0.625–2.50 mc/sec, sound waves being sent from water into the gel. Measured angles of incidence, at which the emergent rays are totally reflected, allow calculation of velocities of longitudinal and transverse wave and, thus, of the Young's modulus, Poisson ratio, and bulk modulus. Elastic constants are plotted against aging time, temperature, and frequency. Young's modulus is of the order of about 1/100 that for iron. The decrease of Young's modulus with temperature is explained by the assumption of a double layer at the surface α of the particles, breaking down at 60 to 70 C by giving out water. Temperature function of the bulk modulus is calculated on the basis of Boltzmann law in agreement with experiment, and leads to a hypothesis on the formation of a gel from a sol. O. Ruediger, Germany

1091. **Bowden, F. P., and Young, J. E., Friction of clean metals and the influence of adsorbed films,** *Proc. roy. Soc. Lond.* (*A*) 208, 1094, 311–325, Sept. 1951.

Authors describe the apparatus, test procedure, and results of friction tests for clean metals. The metals were cleaned in a vacuum and at an elevated temperature. The test metals were nickel on nickel, iron on iron, platinum on platinum, and uranium on uranium. Tests at room temperature for the clean metals produced values of $\mu \infty 1.7$ to 8.8. A marked tendency for the clean metals to seize at room temperatures was noted.

Influence of surface layers on the clean surfaces was studied by admitting hydrogen, oxygen, water vapor, fatty acids, hydrogen sulphide, and chlorine to the test chamber. The drop in μ was most marked in tests for chlorine on iron.

Results support the theory that the friction of metals is due mainly to adhesion at points where a clean surface comes in contact with a clean surface. Glen N. Cox, USA

1092. **Hanstock, R. F., The non-destructive testing of metals,** London, Institute of Metals, 1951, viii + 163 pp. $3.50.

The preface states that the reader should not be disappointed if the book fails to provide explicit solutions to a specific problem. It contains, rather, a restatement of certain sections of those sciences, mainly classical physics, which have a particular bearing on the nondestructive examination of metals.

Author divides this material into 14 chapters and compresses this broad field into a book of 150 pages; according to the author, each chapter could be expanded into a separate volume. The value of the book, then, depends not only on the presentation of the material but also on its selection.

The presentation of the chapters—Introduction; Measurement of thickness; The evaluation of surface finish; Detection of cracks at or near the surface; Radiography; Detection of flaws by ultrasonic methods; Dynamic tests; Damping capacity: definitions and methods of measurement; Damping capacity: dependence on metallurgical condition; Damping capacity: theoretical aspects; X-ray diffraction: introduction; X-ray diffraction: applications; Electrical and magnetic methods of estimating composition and condition: some methods of analysis—is done in an easily understandable and concise form. An adequate bibliography is attached to each chapter. Of particular interest should be the appendix which contains a table summarizing nondestructive testing methods for thickness measurements, identity of dimensions, surface finish, detection of defects (cracks and flaws), analysis of composition, mechanical properties, residual stress, physical state.

It is difficult to decide the type of engineer or scientist to whom this book is directed. The information selected does not seem to be of great value to the practical testing engineer (since the discussion of the applicability of the various testing methods is rather superficial), or to the scientist working in this field who will be familiar with the greater part of the information from the study of more comprehensive literature. The book, however, may be of some value to the specialist who has been presented with a nondestructive testing problem out of the ordinary, and who is searching for some ideas for his specialized case.

The engineer who wants to acquaint himself with the field of nondestructive testing will find the book useful; however, he may be led astray by the importance of the various testing methods, since emphasis is not always placed on the more practical testing methods. A superficial check of the book revealed errors in the equations presented.

It is reviewer's impression that selection of the material has been made rather according to the interests of the author than according to the interests of the prospective reader.

Robert O. Fehr, USA

Mechanical Properties of Specific Materials

(See also Revs. 1074, 1076, 1077, 1083, 1088)

1093. **Tör, S. S., Stout, R. D., and Johnston, B. G., Further tests on effects of plastic strain and heat treatment,** *Welding J.* **30,** 11, 576s–584s, Nov. 1951.

Paper is the sixth in a series describing the results of an experimental project concerned with fabrication effects on the mechani-

cal and physical properties of pressure vessel steels [see AMR **2**, Rev. 1145; **3**, Rev. 2342; **4**, Revs. 2049, 2535]. Reported are the results of slow-notch-bend tests on two steels, which were given various heat treatments after being (1) in their as-received state, (2) subjected to 20% prestraining in tension, parallel and perpendicular to the rolling direction, (3) subjected to 5% cylindrical bending. Analogous tests were also conducted on spherical specimens, after they had been given a hot or cold pressing. Discussion focuses on transition-temperature curves, which have percentage of cleavage and contraction, and energy absorption as criteria.

Prestraining raised the ductility transition temperature over that of the unstrained steel; the transverse straining case showing the greater increase. Similarly, the cold-pressed spherical specimens showed higher transition temperatures than those of the hot-pressed or unpressed steels. The many curves bring out the heat-treatment effects. Julius Miklowitz, USA

1094. Jaffe, L. D., and Buffum, D. C., Reproducibility of bend test for high hardness steels, *ASTM Bull.* no. 177, 36–37, Oct. 1951.

High-carbon alloy steel specimens were given a single heat treatment that produced a Rockwell hardness of C 52½. The strength of these specimens was determined by bending under two-point loading until rupture occurred.

The results thus obtained, together with those in the literature, were analyzed mathematically to determine the minimum number of specimens necessary to determine, with a high degree of certainty, which of two materials has the higher bend strength.

From authors' summary by Henry A. Lepper, Jr., USA

1095. Fukui, S., and Sato, S., On the fatigue of work-hardened steel (3rd Report) (in Japanese), *Rep. Inst. Sci. Technol., Univ. Tokyo* **5**, 6, 259–264, Dec. 1951.

The torsional fatigue limits were studied in the same way as in previous work [see AMR **4**, Rev. 3252]. Arranging the experimental results by the absolute values of natural strain corresponding to the preworking stresses, the fatigue limits changed similarly both for tensile and compressive preworking. Compared with the annealed states, the fatigue limits decreased a few percentage for small strain, and then increased about 15–20% for large strain. This tendency seemed to be similar to that of the proportional limits for torsion, and also to those of the fatigue limits for tension-compression or bending stresses.

From authors' summary

1096. Marin, J., Ulrich, B. H., and Hughes, W. P., Plastic stress-strain relations for 75S-T6 aluminum alloy subjected to biaxial tensile stresses, *NACA TN* 2425, 48 pp., Aug. 1951.

Constant-stress-ratio tests, variable-stress-ratio tests, and special tests were made on a thin-walled tubular 75S-T6 aluminum-alloy specimen by subjecting it to axial tension and internal pressure. Stresses were measured by clip-type SR-4 strain gage. Authors conclude (1) that biaxial yield strength, nominal biaxial ultimate strength, and true biaxial fracture strength are in approximate agreement with both the maximum-stress and maximum-shear theories; (2) that, for constant principal stress ratios, the octahedral deformation theory gives a good approximation for defining the plastic biaxial stress-strain relations; (3) that, for the particular variable-stress tests made, both the deformation and flow theories give a good approximation to the actual stress-strain relations; (4) that, for large plastic strains, the assumption of isotopic yielding made in the plasticity theories is in general agreement with the test results. S. B. Batdorf [AMR **4**, Rev. 219] indicates that the slip theory of plasticity gives better agreement with tests than the octahedral-shear theory used in subject report.

B. E. Gatewood, USA

1097. Lord, G. W., and Willis, T. F., Calculation of air bubble size distribution from results of Rosiwal traverse of aerated concrete, *ASTM Bull.* no. 177, 56–61, Oct. 1951.

The widespread use of aerated concrete makes desirable the determination of the number of different sizes of air bubbles in a unit volume of hardened concrete. The experimental basis for this determination is provided by the Rosiwal method, by which are found the numbers of different lengths of chords intercepted by the air bubbles per unit length of a linear traverse. Knowing the curve of the chord-size distribution, a simple graphical method is derived for determination of the bubble-size distribution, based on some probability relationships, arrived at in earlier works. The application of the method is illustrated by an example. Alexander Hrennikoff, Canada

1098. Jasper, J. M., Law of cement-hardening as a function of time (in French), *Rev. Matér. Constr.* no. 433, 281–291, Oct. 1951.

Author proposes empirical formula $R = K \cdot \log(1 + \log t) + K'$ where R is strength of cement, t time in days, K and K' two parameters. The formula was checked in numerous tests performed with different kinds of cements in accordance with Belgian and ASTM standards and also against requirements for hardening in standards of 14 countries (among them the United States). Formula is valid up to 90 days. While possibly quite useful, it should not be considered as a "law" of hardening, as evident from taking log of a dimensional figure. M. Reiner, Israel

1099. Treloar, L. R. G., Effect of tension on water absorption by hair, *Nature* **168**, 4273, 521–522, Sept. 1951.

By weighing in a definite atmosphere (24 C and 75.5% relative humidity) an assembly of eight horsehairs on which stresses were alternately applied and removed, author found that the water content of the hairs increased with stress. This change, which is contrary to that generally assumed or found elsewhere for human hair, is explained by a relation derived from the usual thermodynamic treatment of swelling pressures.

D. De Meulemeester, Belgium

1100. Abbott, N. J., The measurement of stiffness in textile fabrics, *ASTM Bull.* no. 176, 49–51, Sept. 1951.

Author compares five different laboratory methods of measuring stiffness of fabrics. He finds the Peirce cantilever test [*J. Text. Inst.* **21**, T377, 1930] most convenient and one which gives good correlation with subjective estimates. The application of the cantilever test is discussed in detail and a specific technique for its use is recommended. H. Kolsky, England

1101. Howell, H. G., Inter-fibre friction, *J. Text. Inst. Trans.* **42**, 12, 1521–1533, Dec. 1951.

Two methods of determining the coefficient of friction for fibers have been devised. In the first method (stick-slip or triangle-of-forces method) a horizontal fiber is pressed, for a certain distance s, against another fiber vertically loaded. The reaction between the two fibers is measured by the distance s. The horizontal fiber is then moved along its direction, and the displacement l, till the slip takes place, is noted. The coefficient of friction is given by the quotient l/s. In the second method, incline-plane method, a fiber forms an incline down which the other fiber—forming a loop and loaded—slides when limiting friction is reached. The coefficient of friction is determined by the angle for which slip takes place.

The fibers studied were viscose, cuprammonium, acetate rayon, and nylon. They were tried under different loads. The variation of the frictional force F with the reaction R found by

author is a linear one: $F = R_0 + F_0$ and confirms the results obtained by other workers in their experiments on different fibers. Further experiments made by author confirmed that F_0 is proportional to the contact area A; F_0 is probably not due to a loosely bound moisture film. In a final discussion, author examines how the empirical linear variation of F in function of R can be explained in terms of the modern theory of friction.

D. De Meulemeester, Belgium

1102. **de Vries, H., The dynamic modulus of elasticity of regenerated cellulose fibres in relation to large deformation,** *Appl. sci. Res.* **A3, 2,** 111–124, 1951.

The stress-strain diagram for a viscoelastic material is dependent upon the rate of extension, previous stress-strain history, temperature, relative humidity, and chemical treatment. The diagram at any extension is composed of secondary creep (irrecoverable or plastic extension), primary creep (extension recoverable with time), and immediate elastic extension (instantaneously recoverable).

The last has been shown by author to be a function only of the extension as determined by the dynamic modulus. He uses a standing-wave method, exciting the filaments at 8880 cps by means of a nickel-tube magnetostriction bar at its resonant frequency. He shows that the phase attenuation along the test filaments is negligibly small, permitting the use of a simple relationship where the dynamic modulus is equal to the density of the material multiplied by the square of the velocity of travel of sound through the material.

The dynamic modulus versus extension curves for a variety of regenerated cellulose filaments are of the same shape with a constant modulus up to a critical value of extension, followed by a linear increase up to a few per cent below the extension at break, after which it is constant. The moduli of the various materials at the first critical extension lie approximately on a polytropic curve where the modulus times the critical extension to the 0.63 power equals a constant, 0.173×10^{11} dynes per sq. cm.

Author identifies two yield ranges: A first yield range from the traditional lower yield extension to the upper yield value, and probably a second yield range leading to break. These phenomena are explained in terms of molecular structural changes. In the range of extension below the lower yield value, the molecular network structure is extended without materially disrupting the many secondary valence bonds. The orientation of chain elements (primary valence bonds) with respect to the filament axis is responsible for the increase in dynamic modulus up to the lower yield extension. In the first yield range a combination of two processes takes place: Reduction in lateral secondary valence bonds, causing a decrease in modulus, and, simultaneously, an orientation of chain elements responsible for an increase in modulus, both processes keeping the modulus approximately constant. Once the upper yield value is passed, the modulus increases steadily with the extension by the combined effect of re-establishing lateral order and increasing orientation. A relative movement of chain elements to a new position of equilibrium occurs, and the upper yield value marks a critical energy level.

The second yield range is similar to the first. The critical energy level is provided by the extension at break. Rupture occurs because of the failure of secondary valence bonds to re-establish lateral order. This second yield region is reached only by filaments free of mechanical injury or internal flaws.

Other techniques for the measurement of the dynamic modulus have been developed and applied. Author's method is not unique, but his application and critical analysis of the stress-strain diagram and its interpretation in terms of the molecular structure constitute a real contribution to the understanding of the relationship between molecular structure and mechanical performance of viscoelastic materials.

Rogers B. Finch, USA

1103. **Bond, W. L., Mason, W. P., and McSkimin, H. J., Elastic and electromechanical coupling coefficients of single-crystal barium titanate,** *Phys. Rev.* (2) **82,** 3, 442–443, May 1951.

The elastic constants were measured by using the ultrasonic pulse method. The constant field elastic constants are obtained as:

$$s_{11}^E = 1.12 \times 10^{-12} \text{ cm}^2/\text{dyne}$$
$$^1/_2 s_{11}^E + {}^1/_4(2s_{12}^E + s_{66}^E) = 0.69 \times 10^{-12}$$
$$c_{33}^E = 1.13 \times 10^{12} \text{ dynes/cm}^2$$

The elastic constants for constant electric displacement are

$$c_{11}^D = 2.06 \pm 0.05 \times 10^{12} \text{ dynes/cm}^2$$
$$c_{12}^D = 1.40 \pm 0.2 \times 10^{12}$$
$$c_{44}^D = 1.26 \pm 0.05 \times 10^{12}$$

Ed.

1104. **Liénard, P., Study of a method for measuring internal friction of plastic coatings submitted to flexure** (in French), *Rech. aéro.* no. 20, 11–22, Mar.-Apr. 1951.

A vibrating bar resting on two supports on its nodes of vibration is a well-defined oscillator. The resonance curve that one obtains with this excited bar, with and without lining, permits calculations to be made of the elastic moduli of the two materials and the energy losses. Comparison is made between the degrees of free oscillations and the experimental results.

From author's summary by Herbert I. Fusfeld, USA

1105. **Krivobok, V. N., and Talbot, A. M., Effect of temperature on the mechanical properties, characteristics, and processing of austenitic stainless steels,** *Proc. ASTM* **50,** 895–928, 1950.

Mechanical properties were determined in the temperature range from −320 to +800 F for AISI grades 301, 302, 304, 310, and 347, rolled either at room temperature or at subzero temperatures. These steels, when cold-worked at room temperature, do not undergo changes in room-temperature properties as a result of holding for 100 hr at −320 F. However, mechanical working of the steels while refrigerated induces greater strengthening than is caused by working at room temperature, as well as improved ductility for a given strength level. All steels, whether annealed or cold-rolled, showed increased strength at subzero temperatures and a different distribution of tensile test elongation.

George V. Smith, USA

1106. **Sharp, D. E., and Ginther, L. B., Effect of composition and temperature on the specific heat of glass,** *J. Amer. ceram. Soc.* **34,** 9, 260–271, Sept. 1951.

A simple empirical equation has been established for the mean specific heat of glass as a function of temperature over a range from 0 to 1300 C. Factors have been derived by means of which the constants of the equation may be calculated from the composition of the glass, with an accuracy sufficient for engineering purposes. It is emphasized that no physical significance is attributed to the type of equation nor to the composition factors, and that proof of accuracy at high temperatures is limited by lack of dependable data.

From authors' summary by Derald A. Stuart, USA

1107. **Bush, S. H., Wood, W. P., and Rote, F. B., Comparative surface-hardening characteristics of commercial pearlitic malleable irons,** *Trans. ASME* **73,** 8, 1093–1099, Nov. 1951.

Nine pearlitic malleable irons, produced by commercial foundries and exhibiting wide differences in chemical composition,

production practices, and microstructures, have been investigated to determine the hardness and effective case depth with different surface-hardening heat treatments. Flame- and induction- (3000, 9600, and 300,000 to 347,000 cycle) heating, followed by oil, water, or spray quenches have been used for the surface-hardening treatments. Case hardness and depth were determined by superficial Rockwell or Rockwell C measurements and metallographic examination of etched specimens. Of the structures investigated, one, a dense pattern of extremely small spheroids of cementite, was most responsive to all types of treatment. However, it was found in surface-hardening that at all frequencies an optimum power input existed which minimized the influence of microstructure to a pronounced degree.

From authors' summary

1108. Johnson, J. B., and Shinn, D. A., Effect of low temperatures on aircraft metals, *Prod. Engng.* **22,** 10, 187–192, Oct. 1951.

Paper deals with changes occurring in strength and ductility of aircraft metals at subzero temperatures as revealed by commonly accepted tension, fatigue, and Charpy impact tests. Materials investigated were 248-T4, 758-T6 aluminum alloys, FS-1h magnesium, commercially pure titanium, SAE 2330, 4340, 8630, type 304 stainless, and Hy Tuf steels. Tensile and fatigue properties of the metals are given for various temperatures down to −320 F. Charpy impact values are presented for temperatures to −420 F. Authors do not attempt physical explanation of metal behavior but discuss and interpret test results in terms of their importance to aircraft designer and fabricator. G. M. Sinclair, USA

Mechanics of Forming and Cutting

(See also Revs. 1105, 1127)

1109. Pigott, W. T., Pressure developed by viscous materials in the screw extrusion machine, *Trans. ASME* **73,** 7, 947–954, Oct. 1951.

Author's principal object is to determine the behavior of rubberlike materials in the screw pump. The well-known theory of the pump is verified for all discharge rates using oil. Author finds that rubberlike materials behave elastically at open discharge and the mechanism of discharge is sliding friction. At closed discharge, the pressures are calculated for a tightly fitting screw of high width/depth of trough ratio. Comparison of theory and experiment leads to conclusion that mechanism is viscous shearing. Zero discharge pressure is found directly proportional to screw length but not to screw speed. The pressure-discharge rate is not inverse linear as for a Newtonian fluid. Author concludes that rubberlike materials at closed discharge behave as viscous, but highly thixotropic fluids.

J. F. W. Bishop, England

1110. Akun, F., Surface finish and vibrations in turning (in French), *Rev. gén. mécan.* **35,** 29, 31; 138–146, 219–224; May, July 1951.

Tests established that surface finish is influenced by vibrations between tool and workpiece. The frequency of vibration of workpiece and tool is never the same. Amplitudes of vibration constitute a measure of surface finish obtained. Frequency of fundamental vibration of the tool-tool post in all directions is between 110 and 170 cps. Frequency of the small harmonics is of the order of 3000 cps. Vibration of the tool can be considered as that of a cantilever beam and constitutes only a harmonic vibration of the total tool-tool post vibration. This has been verified by measuring the vibration of the tool post which, on the other hand, is influenced to a certain degree by the vibration of the tool. Measurements of displacement, speed, and acceleration of vibrations in the x, y, and z axis were taken with a seismographic Philips instrument. Surface finish was measured with a brush surface analyzer.

Workpiece materials tested: Mild and medium steel, gray cast iron. Tool materials tested: HSS and carbide.

It was found that tool vibrations due to overhang are only weak harmonics in relation to the total vibration of the tool. Tool vibrations (except due to cratering), if one considers the amplitudes of displacements, have only little effect upon the vibration of the workpiece. Tests showed that the existing vibrations, whether those of the tool, the workpiece, or those independent of the cut in each part of the machine, are extremely complicated; they are composed almost always of a fundamental and harmonics superimposed on the fundamental. However, for the tool there are rare cases where the radial vibration is not harmonic. This occurs when the overhang is very small. It was found that the form, amplitude, and frequency of vibration are subject to changes. Vibrations of the tool seem to be most simple, probably because of the simplicity of the tool arrangement characterized by the overhang and a support which produces a simple determinative vibration. Vibrations of the workpiece are due to several sources among which are the drive motor, speed box, belts, and, prominently, the vibrations of the bearings.

The harmonics are the principal influence upon surface-finish roughness. Waviness and roughness of surface are independent of one another; roughness depends mainly upon the harmonics while the waviness is affected by the fundamental vibration during the cut. The harmonics have frequencies between 2000–4000 cps causing a visible rough spot every 0.006 to 0.040 in. (depending upon cutting speed and frequency). Fundamental vibrations cause waves of a length between 0.2 and 1.2 in. on the workpiece surface and are not visible to the naked eye.

When turning steel at a cutting speed of about 100 fpm, with 0.020-in. depth of cut and a feed of 0.004 in., the surface finish obtained with carbide tools was between 40 to 220 microinches and 32 to 160 microinches when the cutting speed was increased to 500 fpm. A similar improvement was obtained when cast iron was turned at higher cutting speeds.

A. O. Schmidt, USA

Hydraulics; Cavitation; Transport

(See also Revs. 1053, 1125, 1261)

1111. Barbe, R., Laboratory measurements of head losses in commercial pipelines, *Wwys. Exp. Sta. Transl.* 51-10, 25 pp., Nov. 1951.

See AMR 2, Rev. 74.

1112. Holdsworth, J. F., Pritchard, F. W., and Walton, W. H., Fluid flow in ducts with a uniformly distributed leakage, *Brit. J. appl. Phys.* **2,** 11, 321–324, Nov. 1951.

Paper presents a straightforward application of the laws of flow in ducts and orifices to the problem of a leaky duct, and a model experiment is described which confirms the analysis when the leakage rate is of the same order as the delivery rate. The results of the analysis relate the pressure drop, inlet flow rate, and outlet flow rate to the pressure drop and flow rate in a similar leakless duct, and a nomograph is given for relating these quantities when the resistance and leakage constants are given.

The problem of the effect of leakage on the friction in the duct or at bends from the aspect of the change in flow pattern is not considered. G. H. Lean, England

1113. **Ueberreiter, K., and Orthmann, H.-J., Viscosity of glassy selenium from 0°–100° C** (in German), *Kolloid Z.* **123**, 2/3, 84–91, Aug./Sept. 1951.

1114. **Doolittle, A. K., Studies in Newtonian flow. I. The dependence of the viscosity of liquids on temperature,** *J. appl. Phys.* 22, 8, 1031–1035, Aug. 1951.

In order to explore dependence of viscosity of liquids on temperature, author measured viscosity and density of compounds belonging to the homologous series of the n-paraffin hydrocarbons over a range of temperature from −10 C to 300 C. He proves the expressions hitherto proposed by investigators for dependence of viscosity on temperature and finds that only the Walther equation $\log \log (v + 0.8) = A \log T + B$ and the Guzman-Andrade equation $\eta = Ae^{B/T}$ reproduce the data over extended ranges of temperature. Yet these equations also give deviations which are much greater than the accuracy of measurements. In search of a better expression, author finds that he obtains a regularity, if he plots the slopes of the $\ln \eta - 1/T$ curves against $\ln \eta$. In evaluating this regularity author attains the differential equation $d(\ln \eta)/d(1/T) = 500 \ln \eta + 4023 + A(T - 373)$ with $A = 4.54$ for compounds with a molecular weight $m < 240$ and $A = (500/T + 127) \cdot (-2 \ln \eta - 5)$ for compounds with $m > 240$. Integration of this equation yields $\ln \eta = Ae^{500/T}[-Ei(-500/T)] - 4.66 + C_1e^{500/T}$ for $m < 240$ and $\ln \eta = -3.31 - 25(1 + 30z + 30.29z^2 + 30.29.28z^3 + \ldots + 30!z^{30}) + C_2(27.1z)^{31}e^{1/z}$; $z = 1/27.1(1 + 127/T)$ for $m > 240$. The constants C and C_2 depend on the molecular weight of the compound. This relationship reproduces viscosities within the accuracy of measurements.

Because of the complexity of the expressions, author believes that viscosity does not depend primarily on temperature but on some property of liquids (for example, the relative free space) that is itself affected by changes in temperature.

Ulrich Rost, Germany

1115. **Bonilla, Ch. F., Brooks, R. D., and Walker, Ph. L. Jr., The viscosity of steam and of nitrogen at atmospheric pressure and high temperatures,** Gener. discuss. heat transfer, London Conf., Sept. 11–13, 1951, Sect. II. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., 7 pp.

Authors extend and modify V. Vasilesco's [*Ann. Phys.* **20**, 137–176, 292–334, 1945] experimental and theoretical methods. Viscosity values for air, Ar, O_2, CO_2, steam, and moist air are given, and previous results are analyzed. Linear viscosity-temperature T relation for $0 < T < 570$ C and a modified form of the Sutherland equation for $570 < T < 1200$ C are recommended for steam. New method is suggested for computing viscosity of moist air, known method is used for correcting to lower pressures; applicability of results therefore extends to high-altitude, high-speed rocket flight and jet engines. V. G. Szebehely, USA

1116. **Lee, S.-Y., and Blackburn, J. F., Contributions to hydraulic control. 1—Steady-state axial forces on control-valve pistons,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51-A-52, 5 pp.

Authors discuss forces due to fluid flow in four-way valves used in oil-hydraulic circuits. By application of momentum equation, the axial flow required to move the valve piston is explained and evaluated. The resulting equation is a close approximation to measured forces. A new port design which produces a negative force is described and the force characteristics roughly predicted by the momentum equation. The experimental results obtained from a model of this design and of a compensated piston, which is a combination of the new parts with conventional ones, are shown in figures. A practical compensated piston is discussed and its performance compared to a conventional one. Reviewer believes paper will be of interest primarily to designers of oil-hydraulic circuits and servo systems. W. D. Baines, Canada

Incompressible Flow: Laminar; Viscous

(See also Revs. 971, 1116, 1161, 1177, 1178, 1185, 1221, 1245, 1263)

1117. **Miyai, Y., On the problem of a stationary vortex of a fluid passing the surface of an obtuse angle,** *J. Japan Soc. appl. Mech.* **4**, 24, 10–15, 1951.

The two-dimensional flow of a real fluid over an obtuse angle at sufficiently high Reynolds number is characterized by the separation of the flow at the vertex of the angle and subsequent reattachment to the boundary. In the region encompassed by the separation, a concentrated vortex appears. Characteristic of the usual mathematical treatment of such problems, author attempts to represent this flow by a hypothetical potential flow with the introduction of boundary adjustments and discontinuities. The boundary adjustment consists of an imaginary extension of the forward side of the angle, a distance l into the flow. The resulting region is conformally mapped into a half plane by an application of the Schwarz-Christoffel theorem. The position and strength required for a single stationary vortex are then calculated. It is found that the vortex can exist anywhere along a line passing through the anticipated area. Selection of the vortex is made on the basis of minimum energy.

Author finds agreement with his experiments is not always good, due partly to difficulty of determining an appropriate value for l which is found experimentally to vary with Reynolds number and the sharpness of the vertex. Author discounts the fact that his solution exhibits pressure discontinuities at the imaginary extension of the boundary because, experimentally, a flexible oil paper substituted for the extension shows very slight deformation.

Since the proper boundary conditions have not been entirely satisfied, reviewer doubts validity of the criterion of minimum energy in choosing the position of the stationary vortex, and believes that a better result might be obtained if the vortex is chosen so as to minimize the pressure discontinuities. In the oil paper experiment, what is important is the effect on the flow, not the deformation of the paper. Leonard Pode, USA

1118. **Scholz, N., On an extension of Glauert's theory of thin airfoils to profiles in cascade,** *J. aero. Sci.* **18**, 9, 637–639, Sept. 1951.

According to Birnbaum's conception of the airfoil problem, each profile of the cascade is replaced by a distribution $\gamma(x)$ of vortexes along its chord, and the velocity induced by this vortex system on the chord (x-axis) is determined. Glauert's procedure of expanding $\gamma(x)$ in a Fourier series is then used to solve the direct plane cascade problem, the coefficients of the series being calculated in the same manner as in Glauert's approximation by simple quadratures involving the shape $y = f(x)$ of the airfoil camber line. Application of proposed method is, of course, limited to cascades of profiles with moderate camber and thickness.

Pierre Schwaar, Switzerland

1119. **Resnick, R., and Green, L. J., Velocity distributions and design data for ideal incompressible flow through cascades of airfoils,** *J. appl. Mech.* **18**, 3, 253–259, Sept. 1951.

By the method of W. Mutterperl [*NACA Wartime Rep.* L 81], the theoretical velocity distributions and turning angles are computed for a cascade with three different blade profiles for various entering angles and solidities. The theory applying the conformal mapping is outlined briefly. A semi-empirical turning-

angle formula as a function of the entering angle, cascade angle, solidity, and camber height is developed using various experimental results. With regard to maximum thickness of the blade, the application of this formula would still be more general, in reviewer's opinion.

The calculated velocity distributions for solidity 1 and blades of 10% thickness show that a peak-free distribution near the nose exists only for a range of entering angles of about four degrees. For the "design-angle," this being the entering angle in the middle of this range, diagrams are given for various cambers.

N. Scholz, Germany

1120. Goldstein, S., Notes on the design of converging channels, *Aero. Res. Counc. Lond. Rep. Mem.* 2643, 14 pp., Mar. 1945, published 1951.

Incompressible fluid in two-dimensional potential motion is to be accelerated from entrance speed V to exit speed U, the area ratio being $a/b = U/V > 1$. It is required that (1) the (relative) channel length l/b be small, (2) no negative velocity gradient occur along the walls because of danger of boundary-layer separation, (3) no re-entrant channel section be admitted. The analysis assumes an infinitely long channel in the z-plane, the boundary of which is mapped onto the perimeter of the unit circle in the ζ-plane, the mapping function involving the complex potential $w(z)$. The channel-wall coordinate z may now be expressed by a line integral in the ζ-plane along a radius of the unit circle, the integrand depending on the velocity distribution through the function $Z = f(\zeta)$, regular on $|\zeta| \leqq 1$, and real for real ζ; actually, Z is a linear function of $\log dw/dz$. Author gives two one-parameter families of functions $f(\zeta)$ by means of which conditions (2) and (3) can be met for every preassigned area ratio. Flows so obtained include some particular channel flows known before.

To investigate condition (1) for a conveniently defined effective length l, the asymptotic behavior of the channel-wall coordinate y is found in terms of large upstream and downstream x, now for general $f(\zeta)$: y approaches $a/2$ (upstream) and $b/2$ (downstream) as $\exp(-\pi|x|/a)$ and $\exp(-\pi x/b)$, respectively; hence much slower on the upstream side. Improvement is only possible when $f'(-1)$, which appears as a factor of the exponential on the upstream side, is assumed to vanish, but this must be paid for by violating condition (2) over the first part of the channel. The paper concludes with numerical results for five examples of $f(\zeta)$ and with an extension of the method to channels of truly finite length. Here l may be made shorter if still more unfavorable deceleration along the wall is admitted. G. Kuerti, USA

1121. Kastner, L. J., and Shih, S. H., Critical Reynolds numbers for steady and pulsating flow, *Engineering* **172,** 4470, 389–391, Sept. 1951.

The purpose of the investigations described was to obtain comparative experimental data on the critical Reynolds number for both steady and pulsating flows through small tubes of several different cross sections. Most of the tests were made on three rectangular tubes. The following are the steady-state results:

Cross sections:	0.0215″×0.500″	0.035″×0.750″	0.044″×1.000″
Critical R:	2010	2290	2240

Under pulsating-flow conditions the critical Reynolds number was always lower than the steady-state value, and varied with frequency. The curves for all three sections were somewhat similar in shape, with maximum values of R occurring around 500 cps, and minimum around 1700 cps. The total frequency range of the apparatus was 200 to 2000 cps.

Some tests were also conducted with tubes of triangular cross section. The steady-state critical Reynolds number was about 750, and the pulsating values below a maximum value of about 680 at 400 cps, falling off at lower and higher frequencies.

These experiments were part of an investigation of the characteristics of a viscous-flow air meter for piston-type internal-combustion engines. Frank L. Wattendorf, USA

1122. Squire, H. B., The round laminar jet, *Quart. J. Mech. appl. Math.* **4,** part 3, 321–329, Sept. 1951.

Navier-Stokes equations in spherical coordinates are solved for a rotationally symmetrical flow (jet). Assuming stream function dependent only on angular coordinate and proportional to r, an ordinary nonlinear differential equation is obtained which can be reduced to a nonlinear first-order equation of the Bernoulli type. A particular integral containing one parameter is obtained.

Streamlines are all similar and show a "throat." Flow is shown to be similar to a jet, with a force in the direction of the axis applied in the origin. Adding heat source in the origin, contour lines of temperature distribution are calculated which coincide with contour lines of radial velocity if Prandtl number equals 1. Results are applied to turbulent jet with constant eddy viscosity. R. Timman, Holland

1123. May, A., Effect of surface condition of a sphere on its water-entry cavity, *J. appl. Phys.* **22,** 10, 1219–1222, Oct. 1951.

An investigation is described of factors which influence the formation of a cavity when a sphere strikes the water surface vertically. It was found that cavities are formed at much lower entry speeds for contaminated spheres than for clean ones, but that there is little dependence on the type of contaminant. In regard to the scaling of this effect, the tendency to form a cavity varies little with size or specific gravity of the sphere. Water-entry cavities are observed to form at velocities much lower than those required for incipient cavitation in the water tunnel; consequently, a relation between the two effects appears improbable. Some dependence of cavity formation on viscosity might be inferred from the observation that cavities were formed at lower entry speeds by spheres coated with liquids of high viscosity than by spheres without this coating.

From author's summary by R. L. Bisplinghoff, USA

1124. McNown, J. S., and Hsu, E.-Y., Application of conformal mapping to divided flow, Proc. First Midwest. Conf. Fluid Dynam. 143–155, 1950.

Two cases of divided flow are presented. Free efflux from a slot in one wall of a two-dimensional conduit, and the efflux from that slot when a barrier, normal to the wall, is placed on the downstream lip so that the effluent flow is directed to a certain distance from the wall.

Authors use an analytical method developed by von Mises and Salzman, consisting mainly in mapping hodograph planes, because hodographs are very simple in these cases, as the velocity is one-directional on fixed walls, or constant along free streamlines. Reviewer recalls [see, e.g., Prandtl-Tietjens, "Fundamentals of hydro- and aeromechanics," McGraw-Hill Book Co., Inc., N. Y., 1934, p. 183; Lamb, "Hydrodynamics," Cambridge Univ. Press, 1932, p. 94] this method is particularly suitable when there are free streamlines and gravitational influence is ignored, so that the velocity is really constant and the hodograph of streamlines is circular. This simple figure is then transformed twice, transforming the imaginary axis in the real axis and, finally, by introduction of the Joukowsky function, $\frac{1}{2}(t + 1/t)$, the circle is mapped on the real axis. Authors apply continuity, Bernoulli and momentum relations and arrive, as did von Mises and Salzman, at final formula which enables them to determine theoretically the contraction coefficient and deviation angle of the jet. Two graphics are presented with these values. Authors

compare these results with Barton's experiments on diverging flow in pipe lines, and, surprisingly, there is good agreement in spite of the fact that the theoretical studies are two-dimensional and the experiments are three-dimensional. Authors conclude that "this theory is expected to be useful as a guide in the interpretation of experimental data" for side weirs, manifolds, and storm sewers. Amando Balloffet, Argentina

1125. **Arnoff, E. L., Re-entrant jet theory and cavity drag for symmetric wedges,** *U. S. nav. Ord. Test. Sta. Inyokern Navord Rep.* 1298, NOTS 368, 28 pp., Mar. 1951.

Theoretical results are restated for two-dimensional flow with finite cavitation number about two cavitation models—single wedge with reentrant jet and tandem wedges with the free streamlines terminating at the wedges. Comparison of careful numerical computations of drag coefficients derived for both models indicate that the greatest difference in coefficient is only 0.16% over a wide range of cavitation numbers and for several wedge angles. Thus, it is concluded that, for practical computations, the mathematically simpler tandem-wedge model is preferable to the physically more correct reentrant jet model.

Phillip Eisenberg, USA

1126. **Snyder, N. W., The cooling of a freely falling water drop,** Gener. discuss. heat transfer, Lond., Conf. Sept. 11–13, 1951, Sect. II. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., 7 pp.

Drops of from 3 to 6-mm diam were caught in a calorimeter at varying distances of fall up to 10 ft. The experimental data for the combined heat and mass transfer were correlated by the expression $Nu'' = 0.29\ Re^{0.6}$ for $Re < 1000$, where $Nu'' = h_i d/\gamma_{da} D$ is the Nusselt number based on enthalpy transfer. Here γ_{da} is the density of dry air, D the mass diffusivity, and d the drop diameter. The enthalpy-transfer coefficient h_i is related to q_i, the rate of enthalpy transfer, according to the defining equation $dq_i/dA = h_i(i_0 = i_\infty)$, where i_0 is the enthalpy at the drop surface and i_∞ is the enthalpy of the ambient air. Using the above relations, equations are derived relating enthalpy transfer to heat transfer, and relating cooling rate to distance of fall.

Two limiting ideal cases are analyzed theoretically; the completely mixed drop in which the temperature is uniform throughout, and the completely unmixed drop in which heat is transferred from interior to surface by conduction alone. Solutions are obtained for both cases relating drop temperature to distance of fall and taking into account both convective and evaporative heat transfer.

Experimental data for cooling rates of drops were found to lie somewhere between the theoretical curves obtained for the two limiting cases. Author concludes that some mixing takes place within the drop during the cooling, but the extent of this mixing is uncertain due to the scatter of the experimental data.

Lawrence Talbot, USA

1127. **Weil, H., On the extrusion of a very viscous liquid,** *J. appl. Mech.* **18,** 3, 267–272, Sept. 1951.

The two-dimensional incompressible flow of a liquid from a large reservoir into a narrow channel is considered. The stream function is found and representation to the channel, to the junction region, and to the "far field" is presented.

George Carrier, USA

1128. **Gotusso, G., A variational principle in plane hydrodynamics** (in Italian), *Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Nat.* (8) **10,** 2, 130–132, Feb. 1951.

Paper deals with steady plane rotational motion of a perfect incompressible fluid. It is known that the stream function ψ of such a motion satisfies $\Delta\psi = -F'(\psi)$, where F is some function and F' its derivative. Author proposes to call $K = \rho_\sigma \int F d\sigma$ the complementary energy (ρ density, σ area occupied by the fluid). He shows that $T - K$, where T is the kinetic energy, has a stationary value for a natural motion when compared with varied motions for which the function F is the same and ψ is unvaried on the boundary. J. L. Synge, Ireland

1129. **Sato, T., On the equations of stationary motion,** *Pap. Meteor. Geophys., meteor. Res. Inst. Tokyo* **2,** 1, 52–57, Mar. 1951.

Author considers Navier-Stokes equations in rectangular coordinates in terms of velocities relative to the rotating earth, subject to the assumptions of (a) steady relative motion, (b) autobarotropy, (c) constancy of the dependent variables in one direction (x-axis). On the basis of the last assumption, a stream function ψ is introduced and, for a frictionless fluid, the momentum equation in the x-direction is integrated along a constant ψ line. The same process is carried out for the vorticity and energy equations. George W. Morgan, USA

Compressible Flow, Gas Dynamics

(See also Revs. 971, 1157, 1160, 1162, 1164, 1193, 1194)

1130. **Goldstein, S., Linearized theory of supersonic flow,** Inst. Fluid Dynam. appl. Math., Univ. Maryland, ii + 22 pp., 1950.

In this lecture series, topics such as some general theorems in linearized theory, conical flows, the methods of sources and sinks, and so on are briefly but precisely stated. The latter half of the lectures is devoted to the techniques of improvement of the linearized approximation, the solution near a singular characteristic, and solution at infinity. Simple examples are cited in these discussions. Y. H. Kuo, USA

1131. **Pai, S. I., Ring shape source distribution in axially symmetrical supersonic flow,** *J. aero. Sci.* **18,** 9, 634–635, Sept. 1951.

Note in Reader's forum.

1132. **Wu, Ch.-H., and Costilow, E. L., A method of solving the direct and inverse problem of supersonic flow along arbitrary stream filaments of revolution in turbomachines,** *NACA TN* 2492, 25 pp., Sept. 1951.

Method is presented for the determination of flow past arbitrary turbomachine blades along stream surfaces of revolution. Importance of the problem from an engineering standpoint does not need to be stressed. Massau's method adjusted by Sauer (1943) to graphical integration (these facts are not mentioned by authors) is applied to cylindrical polar coordinates. Equation of stream function derived by authors in a long way can be derived in a simple way, directly from general tensor form. From a design standpoint, method enables one to construct (approximately) blades for a prescribed velocity or turning distribution around the blades. Results of numerical analysis are given in two cases: Flow in two supersonic cascades, and a partly supersonic nozzle.

M. Z. Krzywoblocki, USA

1133. **White, D. R., Reflection of strong shock at nearly glancing incidence,** *J. aero. Sci.* **18,** 9, 633–634, Sept. 1951.

Note in Reader's forum.

1134. Shen, S. F., and Lin, C. C., On the attached curved shock in front of a sharp-nosed axially symmetrical body placed in a uniform stream, *NACA TN* 2505, 66 pp., Oct. 1951.

Supersonic flow with free-stream direction parallel to body axis is studied for Mach numbers sufficiently large to give an attached shock wave when the body is replaced by an infinite cone with the same semivertical angle. The flow around such a cone is taken as the start and the deviation treated as a perturbation effect. The first-order perturbation turns out to be proportional to the distance from the vertex and thus is small only near the vertex. Higher-order perturbations are discussed, but the first order is studied in detail; tables of the latter are given for three semivertical angles, for each of them for five free-stream Mach numbers. By semivertical angle and free-stream Mach number, the quotient of the initial curvatures of shock wave and body is determined completely; its exact value (positive or negative) is obtained from the first-order perturbation. Higher-order considerations show that regular shock-wave curvature arises only if the body curvature has a logarithmic singularity at the vertex, but in such a way that the initial body curvature is finite. All flow perturbations have singularities at the surface of the cone which would produce the unperturbed flow. For convex bodies these singularities are in the fluid; thus for convex bodies there is a space region in which the flow cannot be approximated by the perturbation method used, since the exact flow cannot have singularities in the fluid. Authors hope that some conclusions (e.g., quotient of initial radii of curvature of shock wave and body) from the perturbation treatment can nevertheless be considered valid also for convex body curvature.

Eric W. Beth, USA

1135. Holt, Maurice, The flow of two adjacent plane superjets past flat-plate wings. II. *Quart. J. Mech. appl. Math.* **4,** 419–431, Dec. 1951.

A procedure similar to part I of this paper [see AMR **4,** Rev. 2112] is used to find the disturbance caused in a stream composed of two adjacent supersonic jets by a delta wing with its apex on the jet boundary and with its leading edge in either or in both jets inside the corresponding Mach semi-cone. It is necessary to consider three cases: (a) Leading edge inside the Mach semi-cone in the port jet, outside the Mach semi-cone in the starboard jet; (b) leading edge outside the Mach semi-cone in the port jet, inside the Mach semi-cone in the starboard jet; and (c) leading edge inside the Mach semi-cone in both jets. First, the flow outside the Mach semi-cones is determined to give the boundary conditions on the Mach semi-cones themselves. The flow inside the Mach semi-cones is then related to one unknown function which must satisfy a certain integral equation.

Neal Tetervin, USA

1136. Wang, C.-T., and Chou, P.-C., Application of variational methods to transonic flows with shock waves, *NACA TN* 2539, 32 pp., Nov. 1951.

Variational methods for the approximate solution of subsonic and transonic flows of a compressible fluid before the occurrence of shock waves have been carried out in previous papers. The methods fail as soon as the shock waves occur, as the flow behind the shock waves now becomes rotational and has variable entropy. Since most transonic flows are accompanied by shock waves, a method which allows for shock waves and variable entropy is necessary for the study of such flows. By modifying Bateman's variational principle for irrotational flows, it is shown that a variational principle for flows with rotation and variable entropy can be obtained. By applying this variational principle to the regions of flow behind shock waves and Bateman's original principle to the other regions in the fluid, shock equations can be directly obtained. A procedure for computing numerical solutions for such flows is suggested and a numerical example is carried out. At high Mach number above a certain limiting value, results show that irrotational flow fails. However, by inserting shock waves and allowing a part of the flow to be rotational, computation indicates that solution exists again.

From authors' summary

1137. Ferri, A., The linearized characteristics method and its application to practical nonlinear supersonic problems, *NACA TN* 2515, 65 pp., Oct. 1951.

Based upon previous work [AMR **3,** Rev. 1321; **4,** Rev. 1650] author extends method to any supersonic flow which can be considered as the superposition of a linearized flow upon a basic flow already known or which can be found by the nonlinear characteristics method. Results are shown to be more accurate than those of a purely linear analysis and, in the case of an ogive based upon conical flow, to be just as accurate as a completely nonlinear calculation. Other cases considered are two-dimensional rotational flow, cones or other slender bodies without axial symmetry, and three-dimensional flows such as wings or wing-body combinations which have a two-dimensional basic flow. Method is applicable to flow fields not amenable to the present method of characteristics and shortens somewhat the labor involved in cases where an exact nonlinear solution is possible.

Robert E. Street, USA

1138. Stewartson, K., On the linearized potential theory of unsteady supersonic motion, *Quart. J. Mech. appl. Math.* **3,** 2, 182–199, June 1950.

Author considers the solution of the linearized equation (1) $c^2\nabla^2\psi = V^2\psi_{zz} + 2i\omega V\psi_z - \omega^2\psi$ for harmonic motion of a thin wing in an idealized, supersonic flow by effecting a Laplace transformation in the streamwise (z) direction and, for three-dimensional cases, a Fourier transformation in the spanwise direction. The specific problems treated are the two-dimensional wing, the wide and narrow delta wings, the semi-infinite rectangular wing, and the slender body of revolution. The potential for the wide delta wing is presented in integral form, and it is shown that the lift and moment coefficients are independent of sweepback, in agreement with previous results [see AMR **4,** Rev. 332]. The solution for the rectangular wing is obtained by analogy to the classical Sommerfeld half-plane problem [H. Lamb, "Hydrodynamics," 6th ed., Cambridge Univ. Press, 1932, p. 538] and agrees with that obtained by the reviewer [see AMR **4,** Rev. 329] but not with that of Stewart and Li [see AMR **4,** Rev. 1267] in giving a tip correction containing only trigonometric (and not Bessel) functions. The solution for the narrow delta wing is obtained by expanding in powers of the frequency, a method that appears to be more amenable to computation than the expansion in orthogonal functions proposed by Robinson [AMR **2,** Rev. 1425] and Haskind and Falkovich [AMR **1,** Rev. 353; translated as *NACA TM* 1257, 1950] and the related expansion proposed by Germain and Bader [AMR **4,** Rev. 380]. Numerical coefficients are given for the first three terms in the expansion of χ in powers of ω^2, where χ differs from ψ by an exponential factor and satisfies an equation of the type (2) $\chi_{xx} + \chi_{yy} = \alpha^2(\chi_{zz} + \lambda^2\chi)$. It is indicated that this same method may be generalized to treat the case of a semi-infinite swept wing, although not without considerable difficulty. Author also includes a brief indication of the formulation of the integral equation for more general wing problems.

J. W. Miles, New Zealand

1139. Fuller, F. B., and Briggs, B. R., Minimum wave drag of bodies of revolution with a cylindrical center section, *NACA TN* 2535, 34 pp., Oct. 1951.

Problem of minimum wave drag for slender bodies of revolution in axial flow and with auxiliary conditions is considered. The bodies consist of front and rear ogival sections connected by a section of circular cylinder. The variational problem of minimizing drag with auxiliary conditions held constant yields a solution in the form of an integral equation for the second derivative of body cross section. The integral equation is transformed to the familiar airfoil equation whose solution is known. The subsequent integrations are performed and the cross-section function for the optimum body obtained. Analysis of the boundary conditions show that, in general, optimum bodies have vertical tangents at the tips; further, the domain of points (k', S_0l/V) is limited to a thin triangular portion of the plane (k' is ratio of cylinder length to body length, S_0 is cylinder cross section, l and V are body half-length and volume, respectively). The drag coefficient $C_D{}^*$ for optimum bodies is expressed in terms of the nondimensional parameters just defined. Holding k' instant, $C_D{}^*$ is parabolic with S_0l/V and has its minimum between extreme values of the parameter. As k' increases, $C_D{}^*$ increases rapidly and the parabolas sharpen. For small k', the increase in $C_D{}^*$ is slow, so that for some situations the increase in volume due to a short cylindrical section ($k' = 0.1$) may offset the small penalty in drag. Drag formulas are presented for various subcases of interest in which three of the parameters l, S_0/l^2, V_0/l^3, and k' are held constant. Agreement is found with calculations made by previous authors. Finally, minimizing wave drag plus skin friction is considered, assuming the optimum bodies to be approximated by prolate ellipsoids of revolution. Here also, the effect of short lengths of cylinder is small. Frederick D. Bennett, USA

1140. **Klunker, E. B., and McLean, F. E., Laminar friction and heat transfer at Mach numbers from 1 to 10,** *NACA TN* 2499, 22 pp., Oct. 1951.

Velocity and temperature profiles in the laminar boundary layer along a flat plate in compressible flow have been computed without imposing restrictions on the thermal properties of the fluid. The free-stream Mach number varies from 1 to 10. Computations are made for ratios of surface temperature to free-stream temperature of 1, 2, and 4 and for insulated surface. The free-stream temperature was taken as -67 F. Experimental values of heat capacity, viscosity, and conductivity are used. Hence the two coupled differential equations which determine velocity and temperature profiles had to be solved numerically with a step-by-step method. Computations are tedious and authors think that the number of examples completed thus far are not sufficient to discuss critically the differences between their results and those obtained by other analyses. Authors suggest that, in heat-transfer computations, instead of the recovery temperature T_r, a newly defined effective temperature T_e should be used as reference temperature. In general, T_e is larger than T_r; for zero heat transfer at the wall, the two temperatures become identical.

I. Flügge-Lotz, USA

1141. **Ackeret, J., Degen, M., and Rott, N., Investigations on wings with and without sweepback at high subsonic speeds,** *NACA TM* 1320, 14 pp., Nov. 1951.

See AMR **3,** Rev. 1984.

1142. **Low, G. M., Simplified method for calculation of compressible laminar boundary layer with arbitrary free-stream pressure gradient,** *NACA TN* 2531, 28 pp., Oct. 1951.

Paper contains application of Pohlhausen method to compressible boundary layer reduced to quasi-incompressible form by Howarth transformation, with known simplifying assumptions and zero heat transfer. Numerical tables are given. Reviewer observes that similar applications have already been made, even with heat transfer, and that, with same assumptions, simpler methods reaching at least equal approximation can be obtained; for instance, using Stewartson-Illingworth transformation and Thwaites' method. Luigi Crocco, USA

1143. **Lock, C. N. H., The ideal drag due to a shock wave. Parts I and II,** *Aero. Res. Counc. Lond. Rep. Mem.* 2512, 17 pp., Feb. 1945, published 1951.

A method involving a number of rather crude assumptions is advanced for calculating the drag of an airfoil at high subsonic speeds. This method was developed by the author in 1939 and is typical of the state of knowledge of transonic flow at that time.

John R. Spreiter, USA

1144. **Chang, C.-C., The aerodynamic behavior of a harmonically oscillating finite sweptback wing in supersonic flow,** *NACA TN* 2467, 76 pp., Oct. 1951.

Author uses Evvard's diaphragm concept [AMR **1,** Rev. 688] to derive two approximate methods for calculating pressure distribution of oscillating finite sweptback wing with both supersonic leading and trailing edges for low values of the frequency parameter, $\omega c/a\beta^2$ [ω angular velocity, c chord, a velocity of sound, and $\beta = (M^2 - 1)^{1/2}$]. The diaphragm contribution to the potential on the wing is cancelled by the contribution of a portion of the wing itself. In the first method, the integrals are expressed in terms of Fresnel integrals. In the second method, a series expansion of source-strength function is used. Accurate results are obtained for frequency parameter less than $1/2$. Graphs are given for the complex pressure distribution (1) on a rectangular wing tip, (2) on sweptback wing tip, for various values of Mach number and frequency parameter. For a rectangular wing, change of frequency parameter has little effect on the in-phase component of the pressure, but has a considerable effect on the out-of-phase component. A. W. Babister, Scotland

1145. **Nelson, H. C., Lift and moment on oscillating triangular and related wings with supersonic edges,** *NACA TN* 2494, 34 pp., Sept. 1951.

Paper and a remarkably similar companion [AMR **5,** Rev. 481] treat the cases of the oscillating triangular wing and related types in pure and mixed supersonic flow. Present paper develops the velocity potential, lift, and moment for the triangular wing and others which can be derived by cutting the rear part so that normal flow to the trailing edges remains supersonic. Solution of the flow equations is obtained to the third power of the oscillation frequency; it is felt that these results are sufficient for practical applications since they satisfy the differential equations to the same power of the frequency.

Loss of aerodynamic damping in pure torsional motion is demonstrated for certain ranges of Mach number and axis or rotation location. Notably, a delta wing of semi-vertex angle less than 45° will not be subject to this instability if the condition of supersonic edges is met. James B. Duke, USA

1146. **van den Dungen, F. H., Note on the Hamel-Synge theorem,** *Quart. appl. Math.* **9,** 2, 203–204, July 1951.

The theorem of the paper is this: The velocity $\mathbf{v}$ of a compressible fluid, moving in a region V bounded by a closed surface B, vanishes on B if and only if $I = 0$, where $I = {}_V\int (\mathbf{A} \cdot \text{curl } \mathbf{v} - f \text{ div } \mathbf{v})\, dV$, f being an arbitrary harmonic function and A a conjugate harmonic vector such that (*) grad f + curl $\mathbf{A} = 0$. For proof, author shows directly that, on account of (*), $I = -{}_B\int [\mathbf{A}\cdot(\mathbf{v} \times \mathbf{n}) + f\mathbf{v}\cdot\mathbf{n}]dB$, where $\mathbf{n}$ is the unit normal to B. Thus, $\mathbf{v} = 0$ on B implies $I = 0$ (necessity of condition). Author

states that, on account of the arbitrariness of the harmonic f, $I = 0$ implies $\mathbf{v} = 0$ on B (sufficiency of condition); this is not clear to reviewer. The condition $I = 0$ generalizes to three dimensions the condition given for plane incompressible motion by G. Hamel [*Göttingen Nachrichten, Math. Phys. Kl.* 1911, 261–270] and with better proof by J. Kampé de Feriet [*Math. Mag.* **21,** 74–79, 1947], and extended to plane compressible motion by the reviewer [AMR **4**, Rev. 1680]. J. L. Synge, Ireland

1147. Vallander, S. V., Equations of motion of viscous gas (in Russian), *Prikl. Mat. Mekh.* **15,** 4, 409–432, July-Aug. 1951.

Equations of continuity, motion, and energy in orthogonal curvilinear coordinates containing terms of diffusion and density heat conduction are considered in this extended version of a previous paper [AMR **4,** Rev. 4538]. Equations are similar to those of Slezkin [AMR **4,** Rev. 3931]. An example treats stationary conduction of heat through a layer of gas between two parallel planes of different temperatures.

Edgar Krahn, England

1148. Hertzberg, A., A shock tube method of generating hypersonic flow, *J. aero. Sci.* **18,** 12, 803–804, 841, Dec. 1951.

Shock-tube methods for producing flow at high Mach number have recently proved successful. Author describes a method for obtaining high supersonic flow in the region of flow just behind the shock by diverging the walls of the duct. Thus, while the Laval nozzle must always expand the flow from sonic speed at the throat, the shock tube can produce a supersonic velocity at the narrowest section, and, for the same area ratio, it will expand the flow to a higher Mach number.

Reviewer believes that further experimental work in the flow region behind the contact surface is necessary before it can be eliminated as a possible source of high supersonic flow. Mach numbers near author's value of 4.2 have been obtained with satisfactory flow conditions behind the contact surface without diverging the tube [*UTIA Rep.* no. 8].

Reviewer believes that author is in error in Fig. 3. Recent measurements made under the supervision of the reviewer show that author's "shock formed by reflections" is a contact surface.

Gordon N. Patterson, Canada

1149. Guderley, G., Two-dimensional flow patterns with a free-stream Mach number close to one, *AF tech. Rep.* 6343, 99 pp., May 1951.

Several new mixed boundary-value problems in two-dimensional transonic flow are considered. First, the Tricomi equation, the approximate transonic form of the hodograph equation, is expressed in terms of new flow variables, each involving both the excess velocity and the velocity direction; sets of basic solutions of the transformed equation are developed. In applying these solutions, two types of boundary conditions are considered: In the first, the stream function and, in the second, a derivative or small perturbation of the stream function are prescribed on the given boundary. Author shows that Tricomi's original problem has a unique solution for the second type of boundary conditions besides that previously established for the first type. He also considers a more general type of contour than that in Tricomi's problem; in particular, part of the supersonic contour may be noncharacteristic. Uniqueness is established in a number of cases where a modified contour has both first and second types of boundary conditions prescribed. The practical transonic problems to which these cases correspond are described. Finally, it is shown that the pressure distribution on a body in a slightly supersonic stream differs from the corresponding distribution in a sonic stream by amounts proportional to the cube of the Mach number excess. Maurice Holt, England

1150. Legras, J., Application of the Lighthill method to a plane supersonic flow (in French), *C. R. Acad. Sci. Paris* 233, 18, 1005–1008, Oct. 1951.

The method developed recently by M. J. Lighthill [AMR 3, Rev. 2405] and G. B. Whitham [AMR **4,** Rev. 1245], giving a first approximation of two-dimensional gas flow, is valid only for great distances from the body. Author analyzes this method and suggests a modified method that represents the flow both at great distances from the body, agreeing with Lighthill's and Whitham's approximation, and also in the neighborhood of the body, agreeing with the usual linearized solution. Method is applied to determination of the shocks in supersonic flow around a profile.

Robert Sauer, Germany

1151. Liepmann, H. W., On the relation between wave drag and entropy increase, *Douglas Aircr. Co., Rep.* SM-13726, 37 pp., Mar. 1950.

Paper presents the theory of the drag problems of bodies moving with supersonic speed. It is not based on the linearized theory of supersonic flows, but on the relations between the drag of the body and the finite entropy increase oblique to the occurring shock waves. Rather than the communication of new results, paper summarizes various simple known relations, where the application of the theory to thin two-dimensional airfoils is especially useful. Here a small wedge angle and, consequently, a weak shock wave are presupposed.

Of interest is the often overlooked result that with interacting of shock wave and Prandtl-Meyer fan, the shape of the shock wave is parabolic and therefore does not have Mach lines as asymptotes. Furthermore, the drag is proportional to the entropy increase only for small entropy rise. Examples are the flat plate airfoil and the biconvex airfoil. It is shown that entropy-drag relations are useful in transonic flow, and the relation between drag and transonic similarity is demonstrated. For a weak shock wave, the entropy rise is explicitly deduced by means of heat conduction and the viscosity influence within a shock wave. Finally, a short proof is given to justify the neglect of the vortex effect in the theory of thin supersonic airfoils.

Manfred Schaefer, Germany

1152. Cramer, R. H., Interference between wing and body at supersonic speeds—Theoretical and experimental determination of pressures on the body, *J. aero. Sci.* **18,** 9, 629–632, Sept. 1951.

Theoretical curves were calculated by means of a new simplified solution for body pressures, based on Ferrari's differential equation [AMR **1,** Rev. 1268; **3,** Rev. 2749], expressed in terms of hyperbolic functions. Experimental data were obtained on a wing-body combination closely resembling the mathematical model treated by Ferrari. Author considers correspondence between theory and experiment to be good, especially since only the first step of theoretical iteration process was employed. Because of neglected boundary layer in the theory, the neighborhood of the jumps shows some discrepancy in the agreement.

Friedrich Keune, Sweden

1153. Oswatitsch, K., and Berndt, S. B., Aerodynamic similarity at axisymmetric transonic flow around slender bodies, *Roy. Inst. Technol., Div. Aero., Stockholm, KTH-Aero TN* 15, 10 pp., 1950.

Similarity laws for the flow around slender bodies with axial symmetry are derived in most general form for subsonic, supersonic, and transonic flow. Mach number, thickness ratio, and ratio of the specific heats may be varied. A formula is given for the change of the pressure distribution for a slender body in

transonic flow with the three mentioned parameters. It is compared with exact computations on slender cones in slightly supersonic flow. Good agreement was reached for a region $0.3 < \tan\theta/\beta < 0.54$ (θ = semi-apex angle of the cone, $\beta^2 = M^2 - 1$). The derived formula depends essentially on an assumption for the behavior of the perturbation potential perpendicular to the axis in the immediate vicinity of this axis.

I. Flügge-Lotz, USA

1154. **Oswatitsch, K., Similarity laws for hypersonic flow,** *Roy. Inst. Technol., Div. Aero., Stockholm, KTH-Aero TN* 16, 12 pp., 1950.

See AMR **5**, Rev. 190.

1155. **Varshavsky, G. A., Behavior of fast moving flow of compressible gas in cylindrical pipe in presence of cooling,** *NACA TM* 1274, 8 pp., Sept. 1951.

Translation from *Zh. tekh. Fiz.* **16**, 4, 1946.

Turbulence, Boundary Layer, etc.

(See also Revs. 956, 1122, 1140, 1142)

1156. **Howarth, L., Note on the boundary layer on a rotating sphere,** *Phil. Mag.* (7) **42**, 334, 1308–1315, Nov. 1951.

The flow caused by a sphere rotating about a diameter in an otherwise undisturbed fluid is considered. The solution on either hemisphere holds up to the immediate vicinity of the equator where it is invalidated by the interaction with the flow from the other hemisphere. By a method similar to that used by Kármán for a rotating disk, author finds

$$\lambda^4 = \frac{231.5}{\sin^{16/3}\theta\cos^{4/3}\theta}\int_0^\theta \sin^{13/3}\theta\cos^{1/3}\theta d\theta$$

$$\frac{u}{\lambda^3 a\Omega\sin\theta\cos\theta} = 0.2357Z - 0.5Z^2 + 0.2929Z^3 - 0.0286Z^4$$

$$\frac{v}{a\Omega\sin\theta} = 1 - 1.5Z + 0.5Z^2$$

Where a is the radius and Ω the angular velocity of the sphere, θ the angular distance of the point considered from the pole of the sphere, $Z(\nu/\Omega)^{1/2}$ the radial distance from the surface of the sphere, and u and v the velocities in the direction θ and in the azimuth direction. $\lambda(\nu/\Omega)^{1/2}$ is the thickness of the boundary layer, ν the kinematic viscosity.

The boundary layer along a thin hollow semi-infinite circular cylinder of radius a, rotating with a constant angular velocity ω about its axis and placed in a uniform stream moving with velocity U parallel to the axis is considered in an appendix. The surface traction has the components

$$\tau_{zx} = 0.332\rho(\nu U^3/x)^{1/2},\ \tau_{xy} = -0.332\rho\omega a(\nu U/x)^{1/2}$$

The drag on the cylinder is unaffected by its rotation. The frictional moment is $M = 1.3282\pi\rho\omega a^3(\nu l U)^{1/2}$ for a length l of the cylinder.

Alb. Betz, Germany

1157. **Moore, F. K., Laminar boundary layer on a circular cone in supersonic flow at a small angle of attack,** *NACA TN* 2521, 44 pp., Oct. 1951.

Author analyzes problem assuming Prandtl number one, viscosity proportional to temperature, and no heat transfer. The outer nonviscous flow is taken from the M.I.T. cone tables. The use of the cone tables is shown to be correct if the boundary layer is much thicker than the so-called "vortical layer" [see AMR **4**, Rev. 1650].

Numerical computations are carried out using a perturbation scheme in the angle of attack with terms of second and higher order neglected. The influence of the angle of attack on the skin friction, viscous lift, viscous drag, and pitching moment are shown.

R. C. Roberts, USA

1158. **Kampé de Fériet, J., Mathematical methods used in the statistical theory of turbulence: Harmonic analysis,** Inst. Fluid Dynamics appl. Math., Univ. Maryland, i + ii + 108 pp., 1951.

Book is based on lectures intended to give a background sufficient for the theory of the spectrum of homogeneous turbulence. Accordingly, the following topics are briefly covered: Functions of bounded variation; the Riemann-Stieltjes and Lebesgue integrals; Fourier transforms and Fourier-Stieltjes transforms. Considerable space is devoted to the Fourier transforms in n dimensions of functions which vanish outside bounded sets, and it is proved that a function is the Fourier transform of a function in L_2, vanishing outside a bounded set D, if and only if it is the sum of a uniformly convergent series $\Sigma a_n\phi_n$, where $\Sigma|a_n|^2 < \infty$ and the ϕ_n's are the Fourier transforms of the functions of an orthonormal sequence of functions which vanish outside D, and which are complete for the class of functions of this type.

The book is necessarily sketchy because of the mass of material covered, and in view of this fact, and of language difficulties, it may sometimes not be clear to a reader unfamiliar with the subject whether a discussion is intended to be a proof or an indication of a possible one. There are a few slips. For example, on p. 12, in subtracting out the jump of a monotone function at a discontinuity, no account is taken of the value of the function at the discontinuity. On p. 13, where absolutely continuous functions are introduced, it is stated that there are monotone continuous functions "having no derivative."

Courtesy of Mathematical Reviews J. L. Doob, USA

1159. **Bloom, M., The effect of surface cooling on laminar boundary-layer stability,** *J. aero. Sci.* **18**, 9, 635–636, Sept. 1951.

Note in Reader's forum.

1160. **Lin, C. C., and Shen, S. F., Studies of von Kármán's similarity theory and its extension to compressible flows. A similarity theory for turbulent boundary layer over a flat plate in compressible flow,** *NACA TN* 2542, 38 pp., Nov. 1951.

First part of paper is devoted to the detailed study of the energy equation. An order of magnitude estimation of the various terms and comparison with available experimental data showed that the turbulent dissipation is not negligible for boundary layers along an insulated flat plate. This term has been neglected by previous investigators. In the second part of the paper, the von Kármán similarity theory is extended to apply to compressible turbulent boundary layers. It is pointed out that this extension is an approximate one, but authors claim that it will be useful in predicting mean velocity and temperature distributions with sufficient accuracy. In developing the similarity concept, the differential equations are linearized by neglecting the fluctuations of density and temperature in comparison with the main quantities, but not the derivatives of the fluctuations. Also, the density and temperature fluctuations are separated into lower- and higher-frequency components, and the similarity concept is assumed to be valid for the lower-frequency components only. Similarity scales for density and temperature distributions are developed. In the final part, it is pointed out that the results of the new theory can be expected to agree only with measure-

ments along a flat plate without pressure gradient. In reviewer's opinion, even though the present status of the theory is somewhat restricted, authors are to be congratulated for their attempt to develop a concept which would allow uniform treatment of velocity, density, and temperature distributions. Such a theory is more than overdue. Paul Torda, USA

1161. Seban, R. A., and Bond, R., Skin-friction and heat-transfer characteristics of a laminar boundary layer on a cylinder in axial compressible flow, *J. aero. Sci.* **18,** 10, 671–675, Oct. 1951.

A solution is given for the case of the laminar boundary layer of an incompressible fluid of constant properties on the exterior of a cylinder with flow parallel to the cylinder axis. This case differs from the Blasius solution for flow along a flat plate by considering the effect of the curvature in a plane transverse to the flow direction. The local skin-friction and heat-transfer coefficients for a Prandtl number of 0.715 are evaluated and compared to the similar magnitudes for flat plate flow, and the effect of the curvature is shown to be significant in some practical cases. Recovery factors are evaluated, and this quantity is found to be insensitive to the effect of curvature of the boundary.

From authors' summary by Tore R. Gullstrand, Sweden

1162. Li, T. Y., and Nagamatsu, H. T., Effects of density fluctuations on the turbulent skin friction of an insulated flat plate at high supersonic speeds, *J. aero. Sci.* **18,** 10, 696–697, Oct. 1951.

Because density fluctuations are not neglected, the well-known relation between shearing stress, density, mixing length, and velocity derivative is replaced by a relation that also contains the density derivative and a parameter α that allows the density derivative to be weighted. Then, by making the usual assumptions, namely, that the mixing length is equal to the product of the distance from the surface and a constant, that the shear in any cross section of the boundary layer is constant and equal to the wall shear, and that the Prandtl number is unity, a friction formula is obtained. For a Reynolds number of 1.1×10^7 and $\alpha = 0$, density fluctuations neglected, the ratio of the friction coefficient at a free-stream Mach number M to the friction coefficient at $M = 0$ is 0.82 at $M = 2$, and 0.34 at $M = 10$; when $\alpha = 1$, density and velocity fluctuations equally important, the ratio of friction coefficients is 0.99 at $M = 2$, and 0.65 at $M = 10$. Authors believe that theory based on fixed value of α may not be adequate and that α should probably increase with M.

Neal Tetervin, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1143, 1144, 1152, 1181, 1198)

1163. Goodman, A., Effects of wing position and horizontal-tail position on the static stability characteristics of models with unswept and 45° sweptback surfaces with some reference to mutual interference, *NACA TN* 2504, 58 pp., Oct. 1951.

Author presents the results of one of a series of tests to provide information on the influence of wing, fuselage, and tail geometry on the static longitudinal and static lateral stability characteristics of present-day airplane designs using a model having various interchangeable parts. Qualitative, and, in several cases, quantitative theoretical explanations are given for the observed interference effects. Author states: "The results indicated that both the unswept and the sweptback low-wing, low-horizontal-tail configurations were the optimum configurations. . . . ."

Leonard Pode, USA

1164. Morrissette, R. R., and Oborny, L. F., Theoretical characteristics of two-dimensional supersonic control surfaces, *NACA TN* 2486, 74 pp., Oct. 1951.

The "Busemann second-order-approximation theory" for pressure distribution over a two-dimensional airfoil in supersonic flow is used to determine, by exact integration, some aerodynamic characteristics of uncambered symmetrical parabolic and double-wedge airfoils with leading-edge and trailing-edge flaps. These are: Flap-effectiveness factor, rate-of-change of hinge-moment coefficient and of midchord pitching-moment coefficient with flap deflection, and location of center of pressure of the airfoil-flap combination.

From authors' summary by T. F. O'Brien, USA

1165. Roy, M., Power versus weight in aviation, *J. roy. aero. Soc.* **55,** 485, 265–281, May 1951 = *ONERA NT* no. 4, 32 pp., 1951.

Paper surveys trends from 1910 to the present in over-all characteristics of high-speed and transport airplanes. Reduction in minimum drag and increase in maximum lift and maximum lift/drag ratio are shown. Weight saving in airframe is discussed, in addition to the increase in wing loading and (asymptotic) decrease in power loading since 1910. Maximum speed and landing-speed trends are shown, together with developments of the power plant. Advantages of a jet for high speed at high altitude are pointed out. Author believes main trend in the near future is for a turbojet assisted by a ramjet at its highest speed, rather than vice versa, since the ramjet, although it is light and simple, has the disadvantage of zero thrust at take-off and at low speeds, and of very high specific consumption at transonic speeds.

Morris Morduchow, USA

1166. Yates, A. H., Dynamic stability of the helicopter: the equations of motion, *Aero. Res. Counc. Lond. curr. Pap.* 47, 7 pp., Jan. 1951.

The equations of motion for small disturbances from forward or backward flight or hovering are given. The six equations of motion of the helicopter are presented in terms of dimensionless derivatives in a manner similar to those presented for fixed-wing aircraft. Raymond A. Young, USA

1167. Nikolsky, A. A., Helicopter analysis, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., Oct. 1951. xi + 340 pp. $7.50.

Author presents various aspects of helicopter analysis. He opens with a review of basic airscrew theories (with special emphasis on vortex theories) and their application to the problems of vertical flight. Simpler approaches to vertical flight (based on momentum theory) are also shown. Discussion of flapping and feathering rotors introduces forward flight. This last is discussed chiefly from the point of view of problems applicable to air loads and stability with rather incidental references to performance. Up to this point, knowledge of simple calculus is sufficient to follow text in spite of its rather mathematical character. In order to soften the impact of Laplace and operational calculus on readers of lesser mathematical background, a special introductory chapter is devoted to mathematical analysis of problems in dynamic stability. The two following chapters discuss dynamic stability of a single rotor helicopter with and without stabilizing devices near hovering and in forward flight. These three chapters have particular value as they present for the first time in a textbook a complete treatment of helicopter dynamic-stability problems. Some readers may regret that the elegant mathematical analysis of stability has no equivalent counterpart in the treatment of the physical side of the problem. However, numerical

examples, if carefully followed through, may compensate this lack to some extent and contribute to the development of feeling about the role and importance of different parameters. The elastic analysis of rotor blades concludes this very valuable addition to the still rather meager helicopter literature.

W. Z. Stepniewski, USA

1168. **Houbolt, J. C., A recurrence matrix solution for the dynamic response of aircraft in gusts,** *NACA Rep.* 1010, 31 pp., 1951.

See AMR 4, Rev. 841.

1169. **Merten, K. F., and Beck, E. B., Effects of wing flexibility and variable air lift upon wing bending moments during landing impacts of a small seaplane,** *NACA Rep.* 1013, 7 pp., 1951.

Subsequent to conducting smooth-water landings of a two-engined flying boat (with greatest center-of-gravity vertical acceleration of about $2g$), authors find that magnitudes and time histories of theoretical wing-root bending moments can be made to agree with experimental results only when contributions of the wing vibrations and of variations in lift are considered. These latter contributions are each found to be of the same order of magnitude as the incremental bending moments resulting from pseudo-static application of the hydrodynamic load, and are independently calculated, respectively, as resulting from measured water loads and from measured attitudes and accelerations. Reviewer believes report to be valuable in adding to knowledge of those phenomena which are currently of concern to individuals responsible for the structural integrity of large aircraft.

T. F. O'Brien, USA

1170. **Brown, H. H., Flight investigation of some factors affecting the critical tail loads on large airplanes,** *NACA TN* 2490, 119 pp., Sept. 1951.

Pitching, yawing, and rolling-pull-out maneuvers were carried out by experienced pilots on a well-instrumented large airplane (Lockheed Constitution: G. W. 184,000 lb). Data were obtained which indicate that customary neglect of tail-load effects upon normal load factors for small airplanes is not an acceptable procedure in determining load factors for large airplanes. Time histories of stock forces, pitching accelerations, normal accelerations, angles of attack and sideslip, horizontal and vertical tail surface pressures, bending stresses in the vertical tail, fuselage bending deflections, and elastic distortion of vertical and horizontal stabilizers are plotted and compared with measurements and predictions of Bouton [*J. aero. Sci.* **16**, 7, 440–441, July 1949], Matheny [AMR **4**, Rev. 1304], Pearson, et al. [*NACA TN* 2078, 1950], and White, et al. [AMR **1**, Rev. 692], as well as with current Civil, ICAO, and Navy airworthiness requirements. The effect of response time-lag upon pilot techniques is discussed, and recommendations are made for additional pilot training to prevent critical loads. Structural deflections of the fuselage, horizontal stabilizer, and vertical stabilizer were found to be of moderate importance.

T. F. O'Brien, USA

1171. **Purser, P. E., and Spearman, M. L., Wind-tunnel tests at low speed of swept and yawed wings having various planforms,** *NACA TN* 2445, 82 pp., Dec. 1951.

Experimental data on the aerodynamic characteristics of swept and yawed wings of various planforms at speeds of 60 and 80 mph are presented in a form which indicates the effect of aspect ratio, taper ratio, and tip shape upon the values of the lift-curve slope and effective dihedral.

The results of the experiments have been compared with the theory of Betz [Betz, A., "Applied airfoil theory. Unsymmetrical and nonsteady types of motion. Vol. IV of Aerodynamic theory"; div. J, ch. IV, sec. 4, W. F. Durand, ed.; Berlin, Julius Springer, 1935, pp. 97–107] and, with proper interpretation of quantities such as aspect ratio, it has been possible to produce good agreement between the experimental measurements and the theory.

Some data on the effects of leading- and trailing-edge high lift devices on sweptback wings at low speeds have also been included, and it is shown that these devices increased the lift-drag ratio and the effective dihedral at high lift coefficients.

Morton Alperin, USA

1172. **Orlik-Rückemann, K., Effect of geometric dihedral on low-speed static stability characteristics of a 40° swept-back wing,** *Roy. Inst. Technol., Div. Aero., Stockholm, KTH-Aero TN* 17, 18 pp., 1950.

Reviewer quotes from author's Introduction and Summary: "Wings with large sweepback angles have often, at high lift coefficients, high negative values of the effective-dihedral parameter. This may result in undesirable effects on the dynamic lateral stability characteristics of such wings. Increasing the negative effective-dihedral parameter corresponds to decreasing the damping of the short period lateral oscillations about the axes of yaw and roll. In order to counteract this effect of high sweepback and keep the effective-dihedral parameter at moderate values, it may be necessary, in many cases, to give the wing a negative geometric dihedral, or to decrease any positive geometric dihedral the wing may originally possess.

"In this report, six component force and moment measurements at low speeds have been made to investigate the effect of geometric dihedral on the aerodynamic characteristics of a 40° sweptback wing of aspect ratio 4.5 and taper ratio 0.5. The results of the tests indicate that, at small ($<10°$) angles of attack and dihedral, the effective-dihedral parameter $C_{l\beta}$ varies linearly with both geometric dihedral and lift coefficient. The variation is of such kind that an increase in $-C_{l\beta}$ caused by the increasing lift coefficient can be counteracted by increasing the negative dihedral. The lift-curve slope $C_{L\alpha}$ at small dihedral angles ($\Gamma < 10°$) varies approximately as $\cos^3 \Gamma$, if the reference area for lift coefficient is taken independent of Γ. Explanation of the variation of moment coefficients with angle of attack is given using the results of a flow investigation."

The report also contains results of wind-tunnel tests illustrating the above characteristics. E. Arthur Bonney, USA

1173. **Yaggy, P. F., A method for predicting the upwash angles induced at the propeller plane of a combination of bodies with an unswept wing,** *NACA TN* 2528, 24 pp., Oct. 1951.

Author showed that simple approximation of upwash angles by addition of those induced by the wing (lifting-line theory), nacelles (extension of Kármán's airship theory), and fuselage (considered to be an infinite elliptic cylinder) gives satisfactory results in comparison with measurements from certain airplane forms [see AMR **4**, Rev. 3029]. Conditions for applying this idealized theory are indicated, for instance, if propeller plane is at least $^1/_2$ chord ahead of unswept wing with moderate or high aspect ratio.

For an isolated nacelle, measurements are given for three variations (basic, conical fairing, conical spinner) and their influence is compared with theory. Friedrich Keune, Sweden

1174. **Weick, F. E., Flanagan, L. E., Jr., and Cherry, H. H., An analytical investigation of effect of high-lift flaps on take-off of light airplanes,** *NACA TN* 2404, 101 pp., Sept. 1951.

This comprehensive design study on the take-off of light air-

planes found the single-slotted full-span flap, with either retractable or plug ailerons or differential flaps for lateral control, as best suited for a four-place personal airplane. Assumed take-off conditions were an accelerated ground run at minimum drag, a circular transition, and a steady climb to 50 ft. Significant parameters turn out to be power loading, span loading, aspect ratio, and ground drag coefficient. The use of suitable high-lift flaps reduced take-off distance by 25%. Shortest distances came with low span and power loadings. Ground and air friction are important only at high span and power loadings. Optimum take-off speed changes only slightly with drag and aspect ratio. The report contains several appendixes, graphs, and charts which detail the compiled information used.

M. G. Scherberg, USA

1175. Melcher, D., Experimental investigation of icing phenomena (in German), *ZAMP* **2**, 6, 421–443, Nov. 1951.

The first part of paper examines the mechanism of icing phenomena. Artificial rime deposits of various types were produced in the wind tunnel and measurements carried out to establish the quantitative dependence of the deposit on temperature, H_2O-content, wind speed, and material of the body to be iced. The growth of the rime on metallic surfaces was observed under the polarizing microscope. Part II describes an arrangement for studying rime in the open air, the purpose of which was to discover whether natural icing is a result of temperature effects (minute differences in temperature between air and solid body). In addition, the influence of an electric field (conductor submitted to direct and alternating tension) on the type of deposit was examined and measured. From author's summary

1176. Gelder, T. F., and Lewis, J. P., Comparison of heat transfer from airfoil in natural and simulated icing conditions, *NACA TN* 2480, 51 pp., Sept. 1951.

1177. Sahliger, K., A simple method for the determination of aerodynamic characteristics of thin profiles (in German), *Öst. Ing.-Arch.* **5**, 4, 310–322, 1951.

Paper provides routine method for application of Birnbaum-Glauert thin-airfoil theory, using interpolation by trigonometric polynomials in close analogy with Multhopp's method in lifting-line theory. Formulas and numerical values are given for use in cases of 3 or 7 pivotal points. Sune B. Berndt, Sweden

1178. Furlong, G. C., and Bollech, T. V., Effect of ground interference on the aerodynamic characteristics of a 42° swept-back wing, *NACA TN* 2487, 24 pp., Oct. 1951.

Wing was tested with inboard trailing-edge flaps and outboard leading-edge flaps deflected and with flaps undeflected, at distances 0.68 and 0.92 of the mean aerodynamic chord above ground board. The observed increase in lift-curve slope and decrease in drag due to ground effect were generally comparable to unswept-wing results. Effects on $C_{L_{max}}$ with and without flaps were also similar to unswept case. Ground effect on pitching moment at stall was generally small, but there was some suspicion that this might not be so at greater distances from the ground.

A. H. Flax, USA

1179. Lush, K. J., A review of the problem of choosing a climb technique, with proposals for a new climb technique for high performance aircraft, *Aero. Res. Counc. Lond. Rep. Mem.* 2557, 15 pp., June 1948, published 1951.

Due to the increase of kinetic energy of aircraft with speed, a new climb technique is proposed for high-speed aircraft to improve its climb performance by building up relatively high kinetic energy at low altitudes, where the available thrust is high for converting into potential energy (i.e., height) at high altitudes. An illustrative example is given. T. H. Lin, USA

1180. Press, H., and McClanahan, H. C., Jr., Flight investigation of the effect of atmospheric turbulence on the climb performance of an airplane, *NACA TN* 2498, 30 pp., Sept. 1951.

Author concludes that average rate of climb is unaffected by turbulence, within experimental error.

H. Reese Ivey, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 1145)

1181. Cunningham, H. J., Analysis of pure-bending flutter of a cantilever swept wing and its relation to bending-torsion flutter, *NACA TN* 2461, 24 pp., Sept. 1951.

It is shown that one-degree-of-freedom flutter in the bending mode is possible on swept wings in potential flow, and that this one-degree-of-freedom bending type flutter arises as the limiting case of classical bending torsion flutter where the torsional stiffness of the wing approaches infinity. The results given are similar to those presented by Smilg where he considered one-degree-of-freedom flutter in pitch of a straight wing. In the theoretical treatment, no attempt was made to include aspect-ratio effects or mutual induction effects arising from change in the mode of vibration in the spanwise direction. Air forces arising from two-dimensional consideration at both $M = 0$ and $M = 0.7$ normal to the leading edge were used in the study. The range of sweep angles at which theory predicts that one-degree-of-freedom flutter may arise is greatly increased by using air forces for subsonic compressible flow.

John E. Stevens, USA

1182. Mentel, T. J., A study of wing torsional divergence, *Nat. aero. Establish., Canad. LR*-2, 11 pp., 3 tables, 27 figs., July 1951.

Two elastic wing models were constructed for the purpose of making an experimental determination of the effect of high wing taper on wing torsional divergence and associated aeroelastic behavior. The wind-tunnel results on these models indicated that existing theoretical divergence speed coefficients may be slightly unconservative for taper ratios around 0.25 or less. In the analysis of the aerodynamic forces on the models, the simple hyperbolic relation was found adequate to express correctly both the lift (including over-all lift-curve-slope) and the rolling moment as functions of the wind speed, wing divergence, and the effective initial orientation as determined by root incidence and twist.

From author's summary by W. P. Targoff, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1032, 1132, 1166, 1173)

1183. Holme, O. A. M., Efficiency of aeroplane propellers at high speed flight, *Roy. Inst. Technol., Div. Aero., Stockholm, KTH-Aero TN* 9, 22 pp., 1950.

Calculations have been made of aerodynamic efficiencies attainable at flight Mach numbers from 0.7 to 0.9 with propellers having tip velocities below the sonic speed. Four types of 6-bladed and 12-bladed single- and contrarotating propellers with a fairly large spinner (in order to avoid compressibility losses at the blade shanks) are examined. The distributions of solidities and lift coefficients along the radius minimizing power losses for a

given thrust loading are determined. The method employed is based on Lock's airscrew strip theory. Compressibility effects are taken into consideration. Results are given by diagrams showing the propeller efficiency as a function of flight Mach number and thrust loading.

Because of partial recovery of energy losses due to slipstream rotation, the contrarotating propellers give higher efficiencies than the single-rotating ones. Due to high values of advance ratios considered in this investigation, differences in efficiency appear to be important. Angelo Miele, Argentina

1184. **Degen, M., Investigation of a contrarotating propeller in a wind tunnel** (in German), *Mitt. Inst. Aerodyn. ETH, Zürich* no. 18, 53–65, 1951.

Systematic tests of a 2 × 2 blade contrarotating propeller, diam 36 cm (14 in.), at various blade angles are described. The blades had a maximum thickness of 14.2% at the root and 5% at the tip; rotational speed was up to 6000 rpm. Test arrangements are described.

A maximum efficiency of 92.5% is obtained, and for rate of advance $V/nD = 0.16 - 0.32$ the efficiency is higher than 90%. The influence of Reynolds number is investigated for one blade angle.

Compared with a single 4-blade propeller, the contrarotating propeller had higher efficiency. The difference was especially great at high rates of advance. Erik Petersohn, Sweden

1185. **Ellis, G. O., Stanitz, J. D., and Sheldrake, L. J., Two axial symmetry solutions for incompressible flow through a centrifugal compressor with and without inducer vanes,** *NACA TN* 2464, 34 pp., Sept. 1951.

For incompressible, frictionless flow, solutions by relaxation method are obtained for centrifugal compressors with an infinite number of straight blades (axial symmetry). The blades have zero thickness. Also, assumption is made that the velocities are directed along the blade surfaces. Three numerical examples are presented. In the first, inducer blades are assumed upstream of the impeller blades, and, for adding a fictitious force field upstream of the inducer blades, zero angle of incidence is achieved at the entrance of the blades. For the second example, the whirl upstream of the inducer is assumed to be zero. In the third example, the inducer blades are removed. In all cases a vaneless diffuser is assumed. Streamlines for all three cases are presented in diagrams and are compared. Lines of constant velocity in the meridional plane are drawn also, and the first and third cases compared. Further, lines for constant values of the tangential component of distributed blade force are also drawn for all three cases. Finally, the variation of the axial component of the velocity between hub and shroud is presented for the first example. Apart from the discussion of the result, some deviations from the assumptions are discussed, namely, the effect if the flow is not directed tangentially to a mean blade surface, and the effects of compressibility, of blade taper, and of angle of attack.

Paul Torda, USA

1186. **Balje, O. E., A contribution to the problem of designing radial turbomachines,** ASME Gas Turb. Power Div., Fall Meeting, Minneapolis, Sept. 1951. Paper 51–F-12, 21 pp.

Paper analyzes the action of radial turbomachines handling compressible fluids to outline a method of predicting the over-all pressure coefficient and efficiency. Each component of the machine is represented by its median flow line, and the effect is expressed by dimensionless work and flow coefficients. These coefficients are presented in terms of Reynolds number, diameter ratios, Mach number, and flow factors, which refer to the size, speed, and shape of the components. Combining the coefficients gives the efficiency and the pressure coefficient in terms of these values. The values also have a definite relationship to design requirements (weight flow, pressure ratio, and inlet condition of fluid); hence a chart is obtained giving efficiency and pressure coefficient related to the design requirements. The influence of blade angle, speed, diffuser type, and diameter ratio on the efficiency and pressure coefficient is discussed. Good correlation between the design chart and test results is shown.

From author's summary by A. H. Church, USA

1187. **Fletcher, J. L., Calculation of airflow through an ejector-operated engine cooling system for a turbojet powered aircraft,** *Douglas Aircr. Co. Rep.* SM-14020, 21 pp., May 1951.

1188. **Himpan, J., The calculation of the volume of rocket combustion chambers,** *Aircr. Engng.* **22,** 257, 191–193, July 1950.

1189. **Peck, J. F., Investigations concerning flow conditions in a centrifugal pump, and the effect of blade loading on head slip,** *Instn. mech. Engrs. Proc.* **164,** 1, 1–15, 1951.

Water flow in a 6-in. single-stage single-entry centrifugal pump, 900 gal/min, was stroboscopically examined through an inspection glass window. Measurements with Pitot tubes at the suction flange, impeller outlet, and in volute casing gave many diagrams of velocity components and swirl angles, indicating interesting vortex flows at different discharges. Three impellers were used, and the influence of movable diffuser vanes was also explored. The head slip due to the limited number of impeller blades, and the mean blade-loading ratio (approximately calculated from net power input) are plotted vs. the discharge. Quotient of both these values seems to be constant for a given type of pump over a wide range of discharge, thus enabling some prediction of effects involved in minor changes in design.

Otakar Maštovský, Czechoslovakia

1190. **Gibson, W. B., Matching torque converters to prime movers,** *Prod. Engng.* **22,** 11, 123–129, Nov. 1951.

How to determine converter size and develop engine-converter performance curve. Ed.

Flow and Flight Test Techniques

(See also Revs. 1141, 1171, 1211, 1264)

1191. **Wegener, P. P., Summary of recent experimental investigations in the N.O.L. hyperballistics wind tunnel,** *J. aero. Sci.* **18,** 10, 665–670, 682, Oct. 1951.

Article presents brief description of 12 by 12-cm continuous blow-down wind tunnel. Condensation is prevented by preheating the supply air, thus allowing attainment of Mach number 8.25. Results of measurements of boundary layer and flow separation are given.

From author's summary by A. Petroff, USA

1192. **Nickel, E., Method for generation, measurement, and regulation of pressure and flow** (in German), *Feinwerktechnik* **55,** 10, 240–246, Oct. 1951.

Paper starts with description of conventional instruments, e.g., Pitot-static tubes, orifice plates, and liquid manometers. Some pointer-reading instruments based on U-tube principle are also mentioned. Remainder of paper deals with use of rotating bent tube to give known pressure difference or flow. By balancing this pressure difference against that given by a Pitot-static tube,

measurements of fluid velocity can be made that are independent of the density of the fluid. Various other applications of the rotating tube are explained, including measurement of rotational speed of a shaft. Reviewer thinks the methods would have few applications in research but might be useful for some industrial purposes. W. A. Mair, England

1193. Holder, D. W., Chinneck, A., and Hurley, D. G., Observations of the supersonic flow round a 6% thick double wedge, *Aero. Res. Counc. Lond. curr. Pap.* 63, 5 pp., 11 figs., Dec. 1950, published 1951.

Surface pressure measurements and flow photographs have been taken for a 6% thick two-dimensional symmetrical double wedge at angles of incidence between 0° and 8°. The free-stream Mach number was 1.57, and the Reynolds number based on chord 0.8×10^6.

Although the results are, in general, in agreement with exact theory, discrepancies occur at the mid-chord where the expansion is observed to be more gradual than would be expected in the absence of the boundary layer, and close to the trailing edge where separation occurs when the airfoil is at incidence. Shock waves were observed at the nose and tail under conditions for which expansions alone would be expected. That at the nose is attributed to the fact that the leading edge was not sharp but 0.001 in. thick, and that at the tail may arise because the tail is blunt or because the flow separates from the other surface of the airfoil.

From authors' summary

1194. Holder, D. W., Chinneck, A., and North, R. J., Pressure measurements in a supersonic tunnel on a two-dimensional aerofoil of R.A.E. 104 section, *Aero. Res. Counc. Lond. curr. Pap.* 62, 3 pp., 12 figs., Dec. 1950, published 1951.

Except in the vicinity of the nose and the tail, the measured pressure distribution on a round-nosed airfoil moving at a supersonic speed is found to be in fair agreement with that calculated for a simple wave giving the measured pressure at the point where the surface is parallel to the free stream. This pressure approximates to the static pressure of the free stream.

The discrepancy at the nose arises from the presence of the region of subsonic flow there, and decreases as the Mach number is raised. The discrepancy at the tail is due to a local separation or thickening of the boundary layer ahead of the tail shock wave, and is particularly pronounced on the upper surface when the airfoil is at positive incidence. From authors' summary

1195. Weltmann, R. N., and Kuhns, P. W., An analysis of an x-ray absorption method for measurement of high gas temperatures, *NACA TN* 2580, 35 pp., Dec. 1951.

The method is applicable over a wide temperature range. The indicated temperature represents the mean gas density. Any mean temperature can be calculated from known temperature profiles. At high temperatures, gas dissociation affects the values of some of the parameters and must be corrected for. Experimental data measured over a temperature range of 1400 to 1700 K, when compared with temperatures measured by thermocouples, substantiate the theoretical equations and emphasize the importance of knowledge of the temperature profiles when calculating mean temperatures from x-ray absorption data.

The theory of operation is based on the ideal gas law and Lambert's law. The ideal gas law is introduced into the modified absorption equation to eliminate gas density. The temperature can then be determined by expressing the temperature and pressure as a function of path length, integrating over the x-ray absorption path length, and solving for the desired temperature using the experimentally determined absorption coefficients.

Experimental tests were run in which an x-ray tube and an x-ray absorbing section were mounted diametrically opposite each other on a 1.5-ft diameter tunnel. Temperatures were measured with thermocouples for comparison. The x-ray absorbing section consisted of a receiving window, vacuum chamber, and Geiger-Mueller counter.

This proposed method is good and should have wide application in fields where temperature measurement using thermocouples is undesirable, but several points must be remembered. First, an accurate knowledge of the gas constituents, as well as temperature and pressure profiles, must be known. Secondly, extreme care must be exercised in the design of the instrument. However, taking all these factors into account, it should be possible to achieve an accuracy of ±4%. Robert J. Mindak, USA

1196. Drury, M. D., Perry, K. P., and Land, T., Pyrometers for surface-temperature measurement, *J. Iron Steel Inst.* 169, part 3, 245–250, Nov. 1951.

Report describes three improved pyrometers designed to measure the temperature of hot surfaces in cool surroundings, with particular reference to the requirements of the steel industry. (1) For temperatures above 900 C, the pyrometer incorporates a back-silvered glass hemisphere which allows nearly black-body radiation in the visible wave lengths to escape through a small hole at the top and be measured by a calibrated barrier-layer photoelectric cell. (2) For temperatures from 300–900 C, the photocell is replaced by a thermopile and the glass hemisphere by a platinum-plated steel one. The effect of different surface emissivities on the calibration of the instrument has been found to be small over a wide range. (3) For temperatures up to 500 C, radiation is concentrated on a thermocouple at the focus of a plated-steel spherical segment. The couple touches the surface but does not rely on perfect contact for accurate surface-temperature measurement. From authors' summary

1197. Wilson, H. W., Continuous-trace recording system for flight testing an "Orenda" gas turbine, *Nat. aero. Establ. Canad. LR*-13, 21 pp., 8 tables, 17 figs., Sept. 1951.

A system is described which is capable of recording simultaneously 74 measurements required for determining the flight performance of an Orenda gas turbine installed in a CF-100 aircraft. These measurements are sensed almost entirely by the use of standard gas-turbine pick-up units and transformed into the deflection of light spots across continuously moving film. The recording equipment and the measurement methods are described in detail. From author's summary

1198. Katzenberger, E. F., An investigation of a rotor blade thermal ice-prevention system for the H-5 helicopter, *Aero. Engng. Rev.* 10, 9, 25–33, Sept. 1951.

Methods of analysis of hot-air ice-control systems are developed. Areas of laminar and turbulent boundary layers on the blade are determined and heat-transfer coefficients computed for both regions. Equations giving heat flow are established. Outside surface temperature along the blade and total heat flow required to maintain these temperatures are determined for the case of dry outside air. Flight test (in dry air) confirmed predicted surface temperatures. At the conclusion, some problems resulting from free water contained in ambient air are considered.

Reviewer finds that heat requirements per square foot of blade area established by the author are considerably lower than generally used by propeller industry. The same applies to helicopter blades when more conservative assumptions are made regarding the extent of turbulent flow and drop of blade surface temperature due to water evaporation. Tests under icing con-

ditions would be most desirable to check actual heat requirements. W. Z. Stepniewski, USA

1199. **Sivells, J. C., and Salmi, R. M., Jet-boundary corrections for complete and semispan swept wings in closed circular wind tunnels,** *NACA TN* 2454, 64 pp., Sept. 1951.

Tables and curves are presented which give values of the induced-upwash-velocity factors, due to the jet boundary, at the horizontal center plane of a closed circular wind tunnel and at that of a closed bipolar wind tunnel which is formed when a reflection plane is installed in a circular tunnel for testing semispan wings. These velocities have been calculated for infinitesimal-span lifting elements located at various points in the horizontal center plane. Inasmuch as the lift distribution of a wing of any planform can be built up from the infinitesimal lifting elements, the induced upwash velocities can be obtained at any point on the wing or, to a limited extent, ahead of or behind the wing. The application of these induced-upwash-velocity factors to the determination of the jet-boundary corrections is also discussed. In order to facilitate the computations, simplified computing forms are presented for evaluating the corrections to the angle of attack and to the drag, pitching-moment, rolling-moment, and yawing-moment coefficients.

From authors' summary by Neal Tetervin, USA

1200. **Lawrence, L. F., Schmidt, S. F., and Looschen, F. W., A self-synchronizing stroboscopic schlieren system for the study of unsteady air flows,** *NACA TN* 2509, 30 pp., Oct. 1951.

Author describes a modified schlieren system using two paths, one to trigger the other. This permits study of cyclic phenomena of fluctuating frequency to 10,000 cps or simulation of continuous slow motion of flow. System is limited to cyclic phenomena where each disturbance has nearly the same shape, size, and time history. C. R. Freberg, USA

Thermodynamics

(See also Revs. 1147, 1221)

1201. **Lisman, J. H. C., Entropy,** *Tech. Wet. Tijdschr.* **20,** 11, 361–368, Nov. 1951.

After a brief review of the entropy concept as used in thermodynamics, the kinetic theory of gases, and statistical mechanics, the author, a Dutch statistician, defines an "entropy" for frequency distribution in analogy to Boltzman's H-theorem in statistical mechanics. In this he follows the recent work of Shannon. Attempts of several other writers (many of them not generally known in America) to introduce entropy functions into various fields such as linguistics, musicology, and economics are then quoted.

Author believes that such a generalization of a physical concept into many disciplines may be of advantage in rendering more intelligible the results in one field to workers in another. The mathematical manipulation of the entropy idea in thermodynamics may facilitate the application of mathematical methods elsewhere. Nevertheless, author is quite aware of the difficulties. If the analogy of the "entropy" in physics and, e.g., economics is nothing more than that both tend toward a maximum, little insight is gained by the use of the same (difficult) term in both fields. The fact, moreover, that entropy in thermodynamics is a statistical concept following relatively simple laws only with reference to closed systems further restricts its analogical use in other fields. In some instances, such as in biology and sociology, a careless neglect of these restrictions has led to false conclusions.

Walter Hitschfeld, Canada

1202. **Bošnjaković, F., Gasification diagrams** (in German), *VDI-Forschungsheft* 432, 27–40, 1951.

Diagrams presented are useful for making heat and material balances around equipment in which coke or coal is gasified by adiabatic reaction with air and water. It is assumed that steady-flow conditions exist and that the following heterogeneous chemical reactions reach equilibrium: $CO_2 + C = 2CO$ . . . [1]; $CO + H_2O = CO_2 + H_2$ . . . [2]; $C + 2H_2 = CH_4$ . . . [3]. Charts are given for calculating the quantity of coke or coal consumed, the quantity of dry gas produced, and its heating value, composition, and temperature.

The simplest charts apply to gasification of pure carbon (coke), with the formation of methane by reaction [3] being neglected. Charts are also given for extending these calculations to solid fuels containing hydrogen, oxygen, and sulfur, and to product gases containing methane. The equilibrium constant used for reaction [3] was about double the newest value reported by the National Bureau of Standards. As a result, the calculated effect of methane formation is too large, but the error is not important unless the total hydrogen content of the gas is large or its temperature is low.

The charts are used to investigate the effect of operating conditions on the production of heating gas and also synthesis gas from coke. For fixed inlet temperatures, the heating value of the gaseous product reaches a maximum as the ratio of water to coke fed to the gas producer increases. This maximum is not so pronounced, however, if methane formation is allowed for. Owing to the bound water that it contains, lignite is gasified with air adiabatically at a lower temperature than coke, but the gas it produces has a slightly lower heating value per unit of mass.

R. L. Pigford, USA

1203. **Fabri, J., Siestrunck, R., and Fouré, C., On calculation of the aerodynamic field of stabilized flames** (in French), *C. R. Acad. Sci. Paris* **233,** 21, 1263–1265, Nov. 1951.

1204. **Prahl, W. H., An algebraic representation of vapor-liquid equilibria,** *Indust. Engng. Chem.* **43,** 8, 1767–1770, Aug. 1951.

Author explains a widely applicable 3-constant equation relating the mol fraction y of a component in the vapor phase to the mole fraction x of that component in the liquid phase. It is based on the definition of relative volatility d by the equation $d = y(1 - x)/x(1 - y)$ and the empirical fact that even for azeotropic mixtures a plot of d against x usually yields a hyperbola within the accuracy of data. The procedure for evaluation of constants is simple, and, if sufficient data are available, shows clearly the consistency of those data. The resulting equation may be used along with the equation of the operating line for algebraic solution of distillation problems. This procedure is usually better than a graphical solution of McCabe-Thiele diagrams; its high precision holds throughout the entire range of compositions. Jack D. Bush, USA

1205. **Babbitt, J. D., On the diffusion of adsorbed gases through solids,** *Canad. J. Phys.* **29,** 5, 437–446, Sept. 1951.

Expressions are obtained for the rate of transport of adsorbed gas through solids by equating the pressure gradient to a frictional force. The frictional force is assumed to be proportional to the number of adsorbed molecules (i.e., resistive force per molecule is constant). The operative pressure has been identified previously [AMR **4,** Rev. 4610] with the spreading pressure of adsorbed gas, which can be obtained from absorption isotherms. Comparison of the theoretical results for Langmuir adsorption with experimental results on the diffusion of H_2 through Cu gives

a satisfactory description of experimental data except at very low pressures. The theoretical result for a BET adsorption isotherm does not predict correctly experimental measurements on the diffusion of water vapor through keratin. A somewhat better fit of the experimental data is obtained if the assumption that the resistive force per molecule is constant is dropped and, instead, the resistive force per molecule is taken to be inversely proportional to the number of adsorbed molecules. In view of the known dependence of the heat of adsorption on the number of adsorbed molecules, the latter assumption appears to be the more plausible. S. S. Penner, USA

1206. **Modes, E. E., Pressure-temperature relations in gas-filled (Class III) thermometers,** *Trans. ASME* **73,** 7, 957–961, Oct. 1951.

Fundamental relations are presented for the pressure in a gas-filled thermometer system in terms of the temperatures and volumes of bulb, capillary, and pressure-responsive element, taking into account a linear volume change of the pressure-responsive element. An example is included in the appendix.

Walter Wuest, Germany

1207. **Shutt, R. P., A theory of diffusion cloud chambers,** *Rev. sci. Instrum.* **22,** 10, 730–736, Oct. 1951.

The diffusion of vapor through a gas downward from a warm to a cold surface is studied quantitatively. The removal of vapor by condensation, the drop growth, and the motion of the drops due to gravity are taken into account. The temperature distribution, necessary for track formation through a given depth of a cloud chamber, is calculated for various gases, pressures, and ionization densities. P. Kriezis, USA

1208. **Carman, P. C., and Raal, F. A., Diffusion and flow of gases and vapours through micropores. III. Surface diffusion coefficients and activation energies,** *Proc. roy. Soc. Lond.* (*A*) **209,** 1096, 38–58, Oct. 1951.

Studies of the adsorption of SO_2 and CF_2Cl_2 on Linde silica II and of CO_2 and CF_2Cl_2 on Carbolac 1 indicate a fairly well-marked distinction between the variation of the surface-diffusion coefficient in (a) the monolayer region, (b) the multilayer region, and (c) the region where capillary condensation is to be expected. For surface coverage less than the complete monolayer, the surface-diffusion coefficient decreases rapidly with decreasing coverage. Surface-diffusion coefficients in the multilayer region are substantially independent of coverage and are of the same order of magnitude as those for diffusion in the liquid state. Marked increases in the surface-diffusion coefficients were observed to occur with capillary condensation. High activation energies preclude the existence of highly mobile or gaslike absorbed layers.

S. R. Faris, USA

Heat and Mass Transfer

(See also Revs. 957, 958, 959, 960, 961, 962, 963, 964, 1106, 1196, 1267)

1209. **Scott, E. J., and Tung, L. H., and Drickamer, H. G., Diffusion through an interface,** *J. chem. Phys.* **19,** 9, 1075–1078, Sept. 1951.

As an example of mass transfer between two phases (solid-liquid, liquid-liquid, liquid-gas), the transport of mass by diffusion in two adjacent slabs is calculated by solution of the two differential equations describing the one-dimensional unsteady molecular diffusion process in both slabs. A finite resistance in the interface proportional to the concentration difference and zero mass flow through the two other boundaries is assumed. Solution is obtained by Laplace transform, and numerical evaluations for four typical examples are presented. E. R. G. Eckert, USA

1210. **Rosenthal, D., and Ambrosio, A., A new method of determining thermal diffusivity of solids at various temperatures,** *Trans. ASME* **73,** 7, 971–974, Oct. 1951.

The experimental technique consists of measuring the temperature-time relation at a point in a long thin rod which is exposed to a moving point source. If the variation of thermal properties is neglected, the solution of the resulting differential equation is an exponential in time. Thermal diffusivity at a particular temperature level may be determined from magnitudes of the source velocity and the slopes of the curve at two points on a semi-log plot of temperature vs. time. The two points employed are at the same temperature—one on the heating and the other on the cooling portion of the curve.

Experimental values for yellow brass are presented in the range 100 to 400 C with a repeat-ability of $\pm 3\%$. They compare favorably with similar values found in the literature.

Method presented is a novel technique for determining thermal diffusivity of solids and is certainly worthy of further consideration and attention. Warren M. Rohsenow, USA

1211. **Letsch, E. R., and King, W. J., Methods of measuring high temperatures in gas streams,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51–A-143, 12 pp., 8 figs.

Conventional methods of measuring temperatures in hot gas streams are subject to large errors, due to heat exchange with surroundings and/or to impact effects at high velocities. The factors affecting these errors are reviewed briefly and their magnitudes under various conditions are indicated in tables and a graph. Paper summarizes the published literature on the subject and the various techniques that have been developed to date. Limitations of these methods are discussed and procedures are recommended for particular conditions.

From authors' summary by Y. S. Touloukian, USA

1212. **London, A. L., Kays, W. M., and Johnson, D. W., Heat transfer and flow friction characteristics of some compact heat exchanger surfaces,** Ann. Meeting ASME, Atlantic City, Nov. 1951. Paper no. 51–A-129, 16 pp., 12 figs., 5 tables.

In a continuation of an extended program [AMR **2,** Rev. 865, **4,** Rev. 3058], data are reported for three types of finned-circular-tube, one small rectangular-tube (aspect ratio 6:1), and one small circular-tube arrangement. Measurements were made for condensing steam to air, with air flow over finned surfaces and through rectangular and circular tubes. Friction factors were measured isothermally and with simultaneous heat transfer. Air-side heat-transfer film coefficients were obtained from over-all data by calculation of the steam-side coefficients and fin ineffectiveness. Results are presented in tables and are correlated by plots of $N_{st} N_{Pr}^{2/3}$ and f vs. N_{Re} for laminar and turbulent flow, where N_{st} is Stanton number, N_{Pr} Prandtl number, N_{Re} Reynolds number, and f friction factor. Heat-transfer results for finned-circular tubes differ from previously available data. The five configurations are compared on a basis of heat-transfer coefficient vs. flow-friction horsepower. R. E. Treybal, USA

1213. **Tranter, C. J., Heat conduction in the region bounded internally by an elliptical cylinder and an analogous problem in atmospheric diffusion,** *Quart. J. Mech. appl. Math.* **4,** part 4, 461–465, Dec. 1951.

A formal solution for the problem of heat conduction in the region bounded internally by an elliptical cylinder, with zero

initial temperature and constant surface temperature, is obtained by use of the Laplace transform. The solution is presented in the form of a summation of integrals involving Mathieu functions. Author then shows that problem of steady-state atmosphere diffusion from a long rectangular strip has a partial differential equation of identical form with the heat-conduction equation; and hence, the solution also applies here.

Reviewer believes the problem to be of theoretical interest, but that tedious numerical calculations would be necessary for numerical evaluation of the solution.

William A. Wolfe, Canada

1214. **Eckert, E. R. G., and Low, G. M., Temperature distribution in internally heated walls of heat exchangers composed of noncircular flow passages,** *NACA Rep.* 1022, 14 pp., 1951.

See AMR **4,** Rev. 1798.

1215. **Blanc, A., Thermic research in the laboratories of Bâtiment et Travaux Publics** (in French), *Ann. Inst. tech. Bât. Trav. publics* (*N.S.*) no. 217, 23 pp., Nov. 1951.

The main subject is the volume of air passing through windows. The measurement of the hourly renewal rate of the air in a room presents numerous difficulties. Author discusses one side of the problem, the air passing through the joints of a door or a window under a pressure difference between the two faces. The relative importance of the different causes of renewal is discussed and the approximate value of the practical pressure differences experienced is given. Comparison of airtightness of window prototypes and the investigation of the efficiency of airtight jointing are made. General problems are then looked into, such as the value to give to a test result on a sample from a large batch. Author concludes with a brief description of research on the accuracy of common measurements of thermal conductivity, hygrometry at the dewpoint, expansion of concretes, and numerical evaluation of the sensation of the skin in contact with the surfacing material of a wall or a floor. From author's summary

1216. **Keyes, F. G., Measurements of the heat conductivity of nitrogen-carbon dioxide mixtures,** *Trans. ASME* **73,** 5, 597–601, July 1951.

Heat conductivity of N, CO_2, and their mixtures (as simplified products of combustion) has been measured at 0, 50, and 150 C and pressures between 1 and 84.3 (resp. 143.4) atm. From Enskog formula for the dependence of gas conductivity on its density, equations have been derived describing influence of pressure and temperature. General relations for binary and ternary mixtures are also indicated. Computed and observed values are compared and, in the discussion (Bryan and Pere), compared with other data, especially from Comings and Nathan, plotted against ratios p/p_{crit} and T/T_{crit}. Periodic fluctuations, found at higher pressures, are explained by combined activity of thermal separation and mass diffusion of mixture components.

Otakar Maštovský, Czechoslovakia

1217. **Fox, R. G., Jr., and Dolch, W. L., A technique for the determination of a thermal characteristic of stone,** *Nat. Res. Counc. Highway Res. Board; Proc. 30th Ann. Meeting,* 180–186, 1951.

A method of determining the thermal diffusivity of stone is described: a spherical specimen is placed in a cylindrical vessel immersed in a thermostat and, after steam is admitted to the cylinder, temperatures at the center and surface of the sphere are read. The thermal diffusivity is calculated using the usual conductivity equation for heat transfer in spheres. The stone was run dry and with the pores saturated with water. The change in thermal diffusivity with percentage of saturation of the pores was large. H. E. Robison, USA

1218. **Short, B. E., and Brown, H. E., Condensation of vapors on vertical banks of horizontal tubes,** Gener. discuss. heat transfer Lond. Conf., Sept. 11–13, 1951. Sect. I. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., 5 pp.

The heat-transfer coefficients were determined for steam and Freon-11 condensing on vertical bank of twenty horizontal tubes; they were 0.625-in. OD and spaced on 1.5-in. center lines.

Nusselt's simplified theory showed that the average condensate film resistance would increase with the fourth root of the number of tubes in the bank; turbulence effects and waves produced by the condensate flowing from the next higher tube apparently reduced the film resistance, and it was found that the average condensate film heat-transfer coefficient is closely approximated by the value predicted by Nusselt's theory for the top tube of the bank. The *Re* for individual tubes varied from about 3.4 to 1200.

H. E. Robison, USA

1219. **Blackwell, J. H., and Misener, A. D., Approximate solution of a transient heat flow problem,** *Proc. phys. Soc. Lond.* (*A*) **64,** part 12, 384A, 1132–1133, Dec. 1951.

Communication presents basic, theoretical, and practical considerations underlying experimental work performed with a view to measuring thermal constants of an infinite medium of low conductivity by a thermal "probe" method. Theoretical treatment uses "large time" and "small time" approximate operational solutions. Authors intend to publish a fuller report at a later date. A. H. Žaludová, Czechoslovakia

1220. **Kondrat'ev, G. M., Application of the theory of regular cooling of a two-component sphere to the determination of heat conductivity of poor heat conductors (method, "sphere in a sphere")** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 4, 536–542, Apr. 1950.

Bicalorimeter is a spherical body formed by a spherical kernel of metal which is surrounded by a concentric layer of poor heat conductor (thermic insulator). Mathematical theory of heat conduction in such solids is well known. If one can calculate with an infinite film-transfer factor between the kernel and the insulating layer, the theory gives simple results suitable for experimental determination of thermal conductivity of the insulator.

The paper deals with two modifications of the "sphere-in-sphere" method. Both of them are very intuitive and can be accomplished without expensive and complicated mechanism. For this reason, reviewer recommends them to physicists and engineers. The second modification especially is very important for the following two advantages: (a) The determination of the thermal conductivity of the insulator can be accomplished without knowledge of its thermometric conductivity. (b) The dimensions of the bicalorimeter can be chosen in such a way that results of sufficient physical and technical exactness can be obtained with even an approximate knowledge (or only with an estimate) of the specific heat of the insulator. V. Vodicka, Czechoslovakia

1221. **Topps, J. E. C., Experimental study of the evaporation and combustion of falling droplets,** *J. Inst. Petrol.* **37,** 333, 535–553, Sept. 1951.

The decrease in diameter of droplets falling at terminal velocities through heated air has been studied for pure hydrocarbons and for hydrocarbon mixtures with initial droplet diameters between 300 and 600μ. Air temperatures were varied from 400 to 950 K and length of fall was 31, 43, or 59 cm. Droplet diameters after fall were estimated by collecting the residues on dry ice.

All of the empirical data are correlated, with reasonable accuracy, by the relation: (total weight loss during fall) × (total friction during fall)$^{-1}$ × (initial diameter)$^{-0.3}$ = const for a given temperature of the air. This empirical relation is examined and a discrepancy noted between the observed dependence of evaporation rate on initial radius and the dependence of heat transfer on initial radius for a droplet settling at terminal velocity according to Stokes' law. Useful correlations are obtained on the assumption that the surface temperature of evaporating droplets is the boiling temperature, provided the air temperature exceeds the boiling temperature by more than 200 C. Swelling of residual fuel droplets is attributed to heat conduction to the interior of the droplet at ambient temperatures below about 680 C. For higher temperatures, thermal cracking of some of the hydrocarbons appeared to occur. Pressure had little effect on the observed evaporation rate, thus suggesting that chemical processes are not rate-controlling in the evaporation and combustion of the falling droplets.

Reviewer believes that experimental studies of the type performed by the author together with more detailed theoretical studies, will ultimately lead to a better understanding of the complex processes involved in heterogeneous combustion.

S. S. Penner, USA

Acoustics

1222. Liebermann, L., Effect of temperature inhomogeneities in the ocean on the propagation of sound, *J. acoust. Soc. Amer.* **23,** 5, 563–570, Sept. 1951.

Horizontal small-scale temperature inhomogeneities in the ocean have been measured with the aid of a highly sensitive, rapid-response thermometer mounted on a submarine. Mean size of these inhomogeneities is of order 60 cm; a typical average temperature variation is 0.05 C. Physical features of inhomogeneities which determine acoustical effects are described by the autocorrelation function; a specially constructed computing machine was used to calculate this function from the temperature records. Calculated backward scattering (reverberation) resulting from these inhomogeneities is given as function of frequency. In region 10 to 100 kc, calculated scattering is, in general, less than that which is actually observed in the ocean, suggesting that biological material is the major source of scattering in the ocean. Calculation of attenuation of transmitted sound in the ocean resulting from scattering shows that this effect is small compared with absorption at higher frequencies. Refractive effects of inhomogeneities result in another acoustical phenomenon: Local warping of wave fronts produces intensity enhancement or diminution at receiver. These effects explain quantitatively the rapid acoustic fluctuations (scintillations) which are observed in the ocean.

From author's summary by A. O. Williams, Jr., USA

1223. Heusinger, P.-P., Measurement of the dependence upon temperature of the velocity of sound in light and heavy water and in water-ethyl alcohol mixtures (in German), *Akust. Beihefte* no. 1, AB3–AB6, 1951.

By means of an ultrasonic optical method, the absolute velocity of sound is measured at room temperature. Its dependence upon temperature is determined at monotonically increasing temperature using alternate resonance and antiresonance of the standing waves formed between quartz and reflector. This method is superior to other similar methods in that it takes only a short time to carry out, and no thermostat is required.

From author's summary

1224. Atkins, K. R., and Chase, C. E., The velocity of first sound in liquid helium, *Proc. roy. Soc. Lond.* (*A*) **64,** part 9, 381A, 826–833, Sept. 1951.

A pulsed ultrasonic method similar to that employed by Pellam and Squire [*Phys. Rev.* **72,** p. 1245, 1947] is used, confirming their results from 4.2 K to 1.6 K and extending the measurements to 1.2 K. The Landau relation $u_2 = u_1/(3)^{1/2}$ is found to disagree by 10% with experimental values extrapolated to absolute zero.

Robert B. Green, USA

1225. Callaway, D. B., Tyzzer, F. G., and Hardy, H. C., Resonant vibrations in a water-filled piping system, *J. acoust. Soc. Amer.* **23,** 5, 550–553, Sept. 1951.

Mechanism of noise transmission was studied below 1000 cps in a straight 2-in. pipe 53 ft long. Numerous high-Q modes were found, longitudinal in either water or pipe wall, and flexural in the wall. Flexural modes are more numerous than others at low frequencies and are also important because of their coupling to radiating surfaces. Observed Q values correspond to attenuations from 0.001 to 0.1 db/ft. Large coupling was found between water vibrations and flexural pipe-wall modes; this bears on the design of noise-reducing devices.

From authors' summary by Philip Rudnick, USA

1226. Middleton, D., On the theory of random noise. I, II, *J. appl. Phys.* **22,** 9, 1143–1163, Sept. 1951.

Papers treat following types of noise: (a) Periodic, nonoverlapping impulse noise; (b) nonperiodic, nonoverlapping impulse noise; (c) Poisson noise. Systems are treated as nonstationary. General formulas are derived in part I for joint probability distributions. Power spectra and correlation functions are given in II.

Papers are highly mathematical. Although applications are discussed, reviewer feels they are difficult to appreciate when abstracted from the mathematical treatment.

Thomas Caywood, USA

1227. Mawardi, O. K., On the generalization of the concept of impedance in acoustics, *J. acoust. Soc. Amer.* **23,** 5, 571–576, Sept. 1951.

The acoustic impedance concept is usually applied to systems having lumped parameters, and to continuous systems having simple wave fields, e.g., plane, spherical, and cylindrical waves. The several types of acoustic impedance are usually considered to be scalar quantities. Author generalizes the concept for fluids by the invention of vector admittance, the quotient of particle velocity (a vector) by the sound pressure at a point. He defines the vector impedance at a point so that it has the same direction as the admittance, and so that the scalar product of the two is unity. For a disturbance, harmonic in time, in a frictionless fluid, he finds the scalar differential equation satisfied by the admittance. He defines the acoustic impedance on a surface as the following complex quotient: The surface integral of the product of the sound pressure and the complex conjugate of the particle velocity, divided by the product of the area of the surface and the surface integral of the absolute value squared of the particle velocity. On the basis of this definition, author finds the acoustic impedances of an area forming part of the wall of an enclosure, of a closed surface void of sources, and of a closed surface containing sources in the neighborhood of obstacles.

Richard K. Cook, USA

1228. Ingård, U., and Bolt, R. H., A free field of method of measuring the absorption coefficient of acoustic materials, *J. acoust. Soc. Amer.* **23,** 5, 509–516, Sept. 1951.

The pressure and phase of an incident plane wave in steady

state are measured at a point in the absorptive surface and compared with the pressure and phase measured at the same point in free space or at the surface of a perfectly reflecting surface. Calculations yield the normal impedance and the absorptive coefficient for the angle of incidence involved. Tests on two materials of known properties give a good check on the validity of the method. Misprints in the theory are confusing; however, the work should be of considerable interest to workers in this field.

A. C. Hagg, USA

1229. **Pippard, A. B., Ultrasonic propagation in liquid helium near the lambda-point,** *Phil. Mag.* (7) **42,** 334, 1209–1223, Nov. 1951.

It is suggested that the sharp minimum in velocity and maximum in attenuation of ultrasonic waves in liquid helium in the region of the λ-point is a consequence of fluctuations which lead to the production of inclusions of He II in He I above the λ-point, and of He I in He II below the λ-point. Expressions are derived for the velocity and attenuation in an inhomogeneous fluid, and are applied, with some modifications, to liquid helium. It is found that the shape of the velocity curve may be accounted for satisfactorily, and that the observed attenuation just above the λ-point requires the inclusions of He II to consist of about 850 atoms. It is shown that fluctuation theory predicts the presence of inclusions of this size in the concentration required to explain the experimental results. From author's summary

1230. **Sette, D., On the ultrasonic absorption in binary mixtures of unassociated mixtures** (in Italian), *Ric. sci.* **21,** 11, 2006–2009, Nov. 1951.

Measurements of the ultrasonic absorption coefficient have been performed in some binary mixtures formed by two unassociated liquids having similar absorption coefficients. The absorption coefficient as a function of the molecular concentration has a minimum at an intermediate concentration. Author also presents a theoretical interpretation of the experimental results.

From author's summary

1231. **Sette, D., Experimental results of measurement of the ultrasonic absorption coefficient in certain liquid mixtures** (in Italian), *Ric. sci.* **21,** 11, 1999–2005, Nov. 1951.

Measurements of ultrasonic absorption coefficient were performed in twelve binary mixtures. In systems formed by an unassociated liquid with high absorption coefficient and another liquid much less absorbing, the absorption decreases very rapidly when small quantities of the other component, whatever its nature, are added to the more absorbing liquid. In mixtures formed by two unassociated and noninteracting liquids having similar absorption coefficients, the curve of the absorption coefficient vs. mol fraction has a minimum. These characteristics of the ultrasonic absorption can be explained by taking into account the increase of the efficiency of collisions among molecules in the energy distribution as a consequence of the presence in the liquid of molecules of different kind. From author's summary

1232. **Spence, R. D., and Granger, S., The scattering of sound from a prolate spheroid,** *J. acoust. Soc. Amer.* **23,** 6, 701–706, Nov. 1951.

Authors state in their abstract: "This paper presents the results of calculations of the scattering of a plane sound wave from a prolate spheroid. Scattering patterns are given for the major axis equal to λ/π, $2\lambda/\pi$, $3\lambda/\pi$, for the ratio of axes equal to 0.10, 0.20, 0.29, 0.37, and for the angle of incidence measured from the major axis equal to 0°, 30°, 60°, 90°."

Reviewer points out that many of the intermediate computations (not published) are very important in obtaining the radar cross section of prolate spheroids in electromagnetic theory. The results published are also valuable as magnitude checks in that field.

In electromagnetic scattering, one usually solves the sound or associated scalar problem in the course of finding the vector solution. Reviewer found such a solution available in the electromagnetic literature ["Scattering by a prolate spheroid," F. V. Schultz, Report UMM-42, Aero. Research Center, Univ. Mich., Mar. 1, 1950]. Schultz obtains a scattering cross section σ in the sound case for a prolate spheroid when the semi-major axis a_0 was 10 times the semi-minor axis and with 2π times the ratio of focal length to wave length equal to 2. The observer was located along the extension of the semi-major axis. Reviewer used that value to check the computations in the article being reviewed. Results were (after conversion was made to put the answers into the same language): σ (Schultz) $= 0.574 \cdot 10^{-3} a_0^2$; σ (Spence, Granger) $= 0.505 \cdot 10^{-3} a_0^2$. Reviewer feels that this is a good check considering that, to obtain these answers, both Schultz, and Spence and Granger had to compute their own tables of prolate spheroidal functions as an intermediate step. Keeve M. Siegel, USA

Ballistics, Detonics (Explosions)

(See also Revs. 1123, 1139, 1188)

1233. **Hodder, G., and Bratt, L. O., Some viewpoints on correction calculations** (in Swedish), *Artill. Tidskr.* **80,** 2, 44–58, 1951.

Paper discusses methods used in Swedish army for determining the total correction on the aim of artillery pieces on the basis of the individual corrections due to variance in atmospheric conditions in the guns, in the powder charges, etc. Due to interaction between the individual corrections, method employed until recently gave rise to errors. A newer method, eliminating this, has been under test, but is more tedious to use, according to the paper. To combine rapid determination of the total correction with sufficient accuracy, and on a theoretically more correct basis, authors suggest a different set of entrance values to be used in the correction tables. The number of entrance values is reduced from nine to six, but this simplification is associated with an increased complexity of the new entrance values. This, in turn, is overcome by the use of charts and suitable tables. Examples, charts, and tables are given, illustrating the method. Paper is difficult to evaluate, partly because full definition of symbols is not given. T. A. Mortensen, USA

1234. **Lenngren, C. E., On thermal stresses in gun barrels** (in Swedish), *Artill. Tidskr.* **80,** 3, 87–111, 1951.

On the assumption that temperature is distributed according to the formula $T = Ar^{-n} + B$ (where A, B, and n are constants) in radial direction and on the usual assumptions of elasticity, author deduces thermal stresses in a gun barrel. From applications of the theory to actual cases, author finds that the assumptions of elasticity are, in general, not satisfied and suggests numerical solutions of the elastic-plastic problem.

Author suggests that the observed network of cracks in the interior of a gun barrel can be explained on the basis of combined action between high thermal stresses and initial scratches.

Frithiof I. Niordson, Sweden

1235. **Rinehart, J. S., Some experimental indications of the stresses produced in a body by an exploding charge,** *J. appl. Phys.* **22,** 9, 1178–1181, Sept. 1951.

In each experiment a cylindrical charge was placed with one

end on a steel plate and detonated from the other end. The plate was then sectioned and examined. Most of the metal displacement was in the direction of the applied force but there were internal brittle fractures due to lateral expansion.

Contours of equal Rockwell hardness were found to be roughly elliptical in shape, with major axes parallel to the plate surface. Static loading would produce much the same pattern. The microstructure was found to contain large numbers of shock twins, however, due to the rapid loading and is mainly responsible for the work-hardening.

Etching revealed a sharply bounded, elliptically shaped region surrounding the depression in the surface. In this heavily worked region, shock twinning was accompanied by extensive slip and breakup of individual grains. H. H. M. Pike, England

1236. Weibull, G., Nomogram for artillery rockets (in Swedish), *Artill. Tidskr.* **80,** 5, 171–182, 1951.

Author has made nomograms for powder rockets driven only in the first part of their trajectory (normally 50–300 m). The nomogram represents the relation between powder weight, total weight, and maximum range for given values of the force of the powder and also of the size and form value of the missile. The powder force is called "the effective specific impulse of the powder," I_{eff} kps/kg. This is calculated after burning in rest and with regard to the stabilization of the missile (rotation, steering fins, etc.).

Author proves that the maximum range (D_{max}) can be represented by a function of I_{eff}, the form value i, the size C, the weight of the powder P_{kr} and the total weight of the rocket P_{tot} (the ballistic coefficient c being determined by i, C, P_{kr}, and P_{tot}). Consequently: $D_{max} = F(I_{eff}, i, C, P_{kr}, P_{tot})$.

Three nomograms are drawn up for the values of I_{eff} (200, 175, and 150 kps/kg). They are drawn in a coordinate system with P_{tot} as abscissa and P_{kr} as ordinate. In this coordinate system a system of curves is drawn, representing different values of D_{max} from 5 to 17 km. A line through the apex of each curve represents the "locus of the best ballistic gain," a sort of "optimum curve."

The nomograms have been calculated for $C = 12$ cm, $i = 0.56$, and $k = 1.475$. (The coefficient k enters into the following equation for the ballistic coefficient c: $10^4 \cdot c = k \cdot i C^2/(P_{tot} - P_{kr})$.)

For different values of C, i, and k, the relation between the "nomogram value" (index n) and the "real value" (index v) is the following:

$$P_{kr_v}/P_{kr_n} = P_{tot_v}/P_{tot_n} = k_v \cdot i_v \cdot C_v^2/k_n \cdot i_n \cdot C_n^2 = 0.0084\, k_v \cdot i_v \cdot C_v^2$$

For values of I_{eff} other than 200, 175, or 150 kps/kg, P_{tot} and P_{kr} can first be calculated with the aid of two of the nomograms, and thereafter the actual values can be interpolated. The use of the nomograms is illustrated by four examples.

For rough estimates in the designing of artillery rockets the nomograms of the author are very useful.

Ragnar Sjöberg, Sweden

Soil Mechanics, Seepage

(See also Revs. 1046, 1053, 1208, 1217)

1237. Armstrong, C. F., Soil mechanics in road construction, New York, Longmans, Green & Co.; London, Edward Arnold & Co., 1950, vii + 215 pp. 85.

Soil mechanics is at the root of modern highway construction and its thorough knowledge has become essential for the highway engineer. After introduction on soil-density moisture relations, author reviews recent history of soil mechanics and soil stabilization for highway construction, pioneered largely in U.S.A. Soil surveys and classification are described generally. Testing of soils, in field and laboratory, is extensively covered and well illustrated, but for test procedures, book refers reader to Brit. Stand. Specif. no. 1377/1948. Proctor compaction, field density and bearing capacity, California bearing ratio, and three laboratory strength tests are among those explained. Only three pages are devoted to design of pavements (flexible pavements only). Chapter on subsoil drainage deals briefly, among others, with electroosmosis, vertical sand drains, pF conception of soil suction and frost action. Soil stabilization is treated with more detail, especially mix-in-place methods and compaction equipment. Glossary of terms and abbreviations and bibliography with references from many countries complete the book.

Reviewer believes that this book, one of the British Roadmakers' Library series, is a good introduction to soil mechanics as used in road construction. Wm. R. Schriever, Canada

1238. Schultze, E., Recent investigations of the bearing capacity of soil foundations, *Wwys. Exp. Sta. Transl.* 51–8, 39 pp., 3 tables, 19 figs., Nov. 1951.

See AMR **2,** Rev. 412.

1239. Caudle, B. H., Slobod, R. L., and Brownscombe, E. R., Further developments in the laboratory determination of relative permeability, *J. Petr. Technol.* **3** (192), 5, 145–150, May 1951.

Paper describes a standardized procedure for obtaining complete relative permeability data on cores with two phases flowing. Capillary pressure curve, specific permeabilities, critical gas saturation have to be measured; relative permeabilities are determined at different saturation, using solution gas, capillary pressure, and dynamic method to obtain the desired value. Results obtained are close to the average data for the field; values, however, are individual as for a unique reservoir.

Solution gas drive relative-permeability method is used to obtain critical gas saturation; it consists of allowing gas to evolve from solution by reducing pressure on a core and flushing excess gas by a flow of dead oil; the same oil serves to obtain relative permeability to oil. Schematic description of the necessary equipment is presented.

By the dynamic relative-permeability method, desired flow rates are obtained by constant-rate positive displacement pumps. Statistical method is described for obtaining average relative-permeability curves to be used in reservoir calculations.

Theoretical and experimental investigations show that the end effect is extremely small where constant rates are employed in the flowing phase. By decreasing total flow rates, permeability to both phases decreases. Initial interstitial water saturation affects considerably the test results.

Apparatus and procedure to be used to obtain relative-permeability data with three phases flowing are also described and some preliminary results are shown. Árpád Kézdi, Hungary

1240. Fatt, I., and Dykstra, H., Relative permeability studies, *J. Petr. Technol. Trans.* **3** (192) 9, 249–255, Sept. 1951.

Based on the capillary bundle hypothesis, theory is presented to express relative permeability as function of saturation, using differential forms of Darcy's and Poiseuille's laws and making an assumption for tortuosity (the ratio of the fluid path length to the length of the core to be inversely proportional to a power of the pore radius). In the final form, pore radius has been eliminated by introducing capillary pressure. To calculate relative permeability, experimental relation between water saturation and capillary pressure is used. Measured and calculated data are in fair agreement.

As to relative oil permeability in water-oil-gas systems, authors suggest considering water as part of the rock matrix with oil as the wetting phase, because the experimental relative oil-permeability curve is typical of a wetting phase curve. Authors describe apparatus for measuring permeabilities at desired water saturation and also give determination of capillary pressure-water saturation curve.

Árpád Kézdi, Hungary

1241. **Haefeli, R., Notes on shear resistance of clayey soils** (in French), *Minist. Obras Públ., Labor Engen. civ., Lisboa Publ.* 17, 14 pp., 1951.

Author recommends the torsional shear method for the condition of drained-soil shear tests and the triaxial method for the undrained tests. In performing the triaxial test, if the lateral pressure is reduced while the axial pressure remains constant, the drained and undrained tests should give the same shear strength for a given axial consolidation pressure. Hence a point T on the common boundary line a between the two states is obtained. Corresponding to every value of consolidation pressure σ_c, there would, of course, be a different T, but all points should lie on the same boundary line. The shearing resistance on the plane of failure, when major principal stresses are higher than σ_c would be approximately constant (line c) and, when lower, would decrease linearly, the slope of the latter (line b) being ϕ_r obtained from measuring the slope $(45° - \phi_r/2)$ of the failure plane, with the major principle stress in the triaxial test. The intercept on the shear axis of the line b gives the cohesion. The torsional shear method may be used to obtain the intersection of line c with line a since the region to the right of line a corresponds to the drained condition.

This method is based on ideal conditions which often do not exist in the field, namely, complete soil saturation at all times and no re-entry of water into the soil pores when $\sigma < \sigma_c$.

Eben Vey, USA

1242. **Hough, B. K., An analysis of the effect of particle interlocking on the strength of cohesionless soil,** *ASTM Bull.* no. 176, 55–60, Sept. 1951.

Direct shear tests were performed on a well-graded sand in such a manner that the interlocking effect of sand grains during shear was evaluated. Special tests were performed in which variations in normal stress compensated for change in area of specimen and for the interlocking effect. These tests indicated that the "true friction angle" for the sand approximated the so-called "ultimate" value obtained from conventional direct shear. The tests, while carefully conducted, are still subject to the influence of factors common to all direct shear tests, such as progressive shear effects and friction between sand and the metal shear frame. Too little is known at the present time of the behavior of cohesionless soil in the immediate zone of shear, especially at very low degrees of strain, to warrant broad conclusions on the application of strength data from the direct or triaxial shear test on cohesionless soils. It is suggested that the author's recommendation to use "ultimate" shear strengths be applied with caution.

Woodland G. Shockley, USA

Micromeritics

1243. **McNown, J. S., and Malaika, J., Effects of particle shape on settling velocity at low Reynolds numbers,** *Trans. Amer. geophys. Un.* **31**, 1, 74–82, Feb. 1950.

Oberbeck's equations are integrated to yield the Stokes law correction factor F for ellipsoids in streamline flow in the direction of any axis of symmetry. Results are given as equations and plots. Surprisingly, prolate spheroids of L/D ratio between 1 and about 3.8 have less drag than a sphere of equal volume, the minimum K of 0.955 being for L/D just under 2.

Settling velocities were determined experimentally in different oils for cubes, spheres, and for equi-axed cylinders and double cones (bases congruent) from 0.0075 to 0.023 ft in diameter, and for the oblate and prolate forms of each having $L/D = 1/4$ and 4, respectively. Up to a Reynolds number of 0.05, each shape settled in its position on release. Settling velocities of all shapes of each L/D agreed within 10%, and usually much better. K averaged, respectively, 1, 1.3, and 1.36 for the equi-axed, prolate, and oblate shapes in motion along their unequal axis.

For Reynolds number exceeding 0.1, only one stable orientation existed, the largest cross section being normal to the motion.

The container diameter D_0 was corrected for by the expression: $K = 1 + 9D/4D_0 + (9D/4D_0)^2$, valid for D/D_0 less than 0.25 and Reynolds number under 0.002.

C. F. Bonilla, USA

1244. **Ramskill, E. A., and Anderson, W. L., The inertial mechanism in the mechanical filtration of aerosols,** *J. Colloid Sci.* **6**, 5, 415–428, Oct. 1951.

Sulfuric acid and DOP aerosols of uniform particle size were passed through eleven widely different filters at velocities up to 280 cm/sec. Percentage of penetration always fell off at high velocities, establishing the significance of the inertial mechanism of interception as well as diffusion and direct interception. Qualitative effects of aerosol size, aerosol density, fiber diameter d_f and interfiber distance d_i are as would be expected. The effective fiber diameter by Albrecht's equation d_e was found to be a direct measure of d_f when $d_i \leqq d_i$, and of d_i when $d_i < d_f$.

C. F. Bonilla, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 1001, 1129, 1175, 1213)

1245. **Phillips, N. A., A simple three-dimensional model for the study of large-scale extratropical flow patterns,** *J. Meteor.* **8**, 6, 381–394, Dec. 1951.

In order to predict the vertical motion in middle troposphere and sea-level pressure tendencies, author constructed a simple two-layer model of homogeneous and incompressible fluids with different densities contained between two horizontal rigid plates. The pressure heights z' and z in the two layers and the height of the interface h are related by the hydrostatic equation. The fundamental equation governing the motion is the equation expressing the conservation of the absolute potential vorticity, from which differential equations of the Poisson type for the height tendencies are obtained by making use of the geostrophic approximation for the vorticities. These equations are solved numerically, by evaluating the coefficient from observations and applying suitable boundary conditions. To relate the pressure heights z' and z in the two layers and the height z_t of the top of the troposphere and z_0 of the 1000-mb surface, the instability properties and phase speed for small perturbations are derived from this two-layer model and compared with that obtained from a continuous baroclinic model. The results are applied to an actual synoptic example, showing that important features of vertical motion and sea-level pressure-tendency patterns can be inferred from the model. Possible improvements of the model have also been suggested.

H. L. Kuo, USA

1246. **Gleeson, T. A., On the theory of cross-valley winds arising from differential heating of the slopes,** *J. Meteor.* **8**, 6, 398–405, Dec. 1951.

A trivial study of the effect of orientation (from N-S) and inclination of valley sides, latitude, and season, on the cross-valley wind. Friction is assumed proportional to velocity; inertial terms like $u\partial u/\partial x$ are ignored without comment; vertical heat-transport mechanism, continuity, and adiabatic heating are not discussed; advection of heat (as of velocity) is omitted, and temperature is assumed to be controlled only by the instantaneous distribution of isolation over a considerable depth. The conclusions which are only qualitative (inevitably!) are concerned mainly with the geometry of the sun's rays, and refer only to the wind near the ground; no attempt has been made to calculate or observe the wind higher up. It can scarcely be said that the equations predict anything useful that could not have been guessed. R. S. Scorer, England

1247. Frenkiel, F. N., Frequency distributions of velocities in turbulent flow, *J. Meteor.* **8,** 5, 316–320, Oct. 1951.

Objective is to use conventional anemometer readings to deduce the rate of diffusion of pollutants, particularly dangerous radioactive ones, in the atmosphere, and to deduce the dangerous area if the source is known. Anemometer does not measure wind direction, so theoretical curves of speed frequency distributions which would be observed by anemometer in various cases of turbulent intensity and anisotropy are calculated on a purely kinematical basis. It is considered premature to compare observed distribution with these; carefully controlled experiments are required first. R. S. Scorer, England

1248. White, R. M., and Jung, G. H., Large-scale atmospheric processes as diffusion phenomena, *J. Meteor.* **8,** 5, 356–358, Oct. 1951.

Many attempts have been made in meteorology to make an analogy between the very large-scale transfer processes in the general circulation, where the individual elements are of the scale of hundreds of kilometers, with the smaller-scale turbulence whose eddies are of the scale of meters. The classical treatment (mixing-length theory) of the smaller-scale turbulence is itself an analogy with molecular processes, and, recently, many doubts have been raised concerning the meaningfulness of this analogy in meteorological problems.

Paper examines the usefulness of a large-scale mixing coefficient, the so-called "grossenaustausch," for processes in the atmosphere in the scale of the travelling cyclones. The "grossenaustausch" for sensible heat is defined as the proportionality factor between the flux and the gradient of this property as measured from synoptic weather maps. Writers were able to obtain values of "grossenaustausch" for the air layer between the ground and about 16,000 ft, latitude by latitude, daily for four winter months. They found that its magnitude ranged between $1\text{–}6 \times 10^7$ gm cm^{-1} sec^{-1}, with a maximum at lat. 55°. They found the fluctuations in the daily values to be so large that an average figure can have little meaning. The fluctuations decreased as longer-period means were taken. Further doubt was shed on the usefulness of the whole approach when the flux of sensible heat was correlated with the temperature gradient, and it was found that, if anything, the flux decreased as the gradient strengthened. Joanne Starr Malkus, USA

1249. Kampé de Fériet, J., Averaging processes and Reynolds equations in atmospheric turbulence, *J. Meteor.* **8,** 5, 358–361, Oct. 1951.

Author considers the class of averaging processes that have the simple properties (e.g., $\overline{f + g} = \overline{f} + \overline{g}$) assumed originally by Reynolds. For the case of atmospheric turbulence, author suggests that eddies larger than the distance l between the measuring points be regarded as contributing to the "mean" flow, and smaller eddies be regarded as "fluctuations"; the corresponding mathematical definition of the average of $f(z)$ is $\overline{f(z)} = \int_{-l}^{l} e^{ikz}\alpha(k)dk$, where $\alpha(k)$ is the Fourier transform of $f(z)$. This averaging method has the required properties except that $\overline{fg}$ is not equal to $\overline{f}\,\overline{g}$, in general. G. K. Batchelor, England

1250. Unoki, S., On the variation of sea level caused by the variation of atmospheric pressure (in Japanese), *J. meteor. Soc. Japan* (2) **28,** 321–339, 1950.

It is well known that a phase lag of a few hours exists between the upheaval of the sea level and the atmospheric pressure minimum. Author attempts to explain this phenomenon theoretically by solving equations of motion on a rotating earth, the frictional force being assumed to be proportional to the velocity. The increase of the phase lag with latitude is explained. S. Syono, Japan

1251. Saito, N., and Ito, K., On the velocity distribution in a simple vortex, *Geophys. Mag., Tokyo* **22,** 4, 283–288, Aug. 1951.

Small gypsum and white-wax balls were used in photographic measurements of velocity distribution in a three-dimensional vortex, created in a water tank. An empirical relation between angular velocity and radial distance from the vortex center is given: $\theta = cr^{-1.61}$. Use of the equation of continuity indicates that the balls do not follow the motion of the water accurately. H. M. Spivack, USA

1252. James, R. W., The structure of steady-state anticyclones, *Austral. J. sci. Res.* (*A*) **4,** 3, 329–343, Sept. 1951.

1253. Sawyer, J. S., and Matthewman, A. G., On the evaluation of terms of a type arising in Sutcliffe's treatment of cyclonic development, *Quart. J. roy. meteor. Soc.* **77,** 334, 667–671, Oct. 1951.

Through the use of a transparent overlay with a printed grid of properly chosen points, it is shown how terms of the form $V \cdot \nabla\zeta$ may be found from weather charts. Here V is a velocity and ζ a vorticity. The orientation of the overlay relative to the V vector permits simplification of the finite differences. Lester Machta, USA

1254. Hitschfeld, W., Free fall of drops through air, *Trans. Amer. geophys. Un.* **32,** 5, 697–700, Oct. 1951.

The free fall in air of water drops up to 1.6 mm diam during the acceleration from zero toward their terminal velocity is calculated under the assumption that the virtual mass of the surrounding air can be neglected due to its low density. The calculated distances of fall check the experimental values within the measuring accuracy. H. A Einstein, USA

1255. Cummings, N. W., Minimum evaporation from water surfaces, *Trans. Amer. geophys. Un.* **31,** 5, part I, 757–762, Oct. 1950.

Author states that under certain conditions evaporation from the water surface is independent of surface temperature, and, therefore, of wind. It occurs when the change of the ratio of convection to evaporation with water-surface temperature is about -0.05 per degree. A particular water-surface temperature yields a minimum evaporation and the maximum discharge of sensible heat by convection. The wind blows away sensible heat instead of water vapor and therefore exerts only a minor influence on evaporation from a lake. The lake evaporation

may, with a remarkably small error, be treated as uniform. The total amount of evaporation can be calculated rather by physical data. Common evaporating pans are insufficient and may be improved. Author checks his statement on the San Diego County lakes with obvious conviction.

Steponas Kolupaila, USA

Lubrication; Bearings; Wear

(See also Rev. 1091)

1256. **DuBois, G. B., Mabie, H. H., and Ocvirk, F. W., Experimental investigation of oil film pressure distribution for misalined plain bearings,** *NACA TN* 2507, 89 pp., Oct. 1951.

A series of qualitative tests were made to determine the effect of misaligning couples on the oil-film pressure distribution in a small bearing. It was found that displacing the load axially along the bearing as little as 16% of the bearing length resulted in large changes in the distribution and magnitude of the pressures and, to a lesser extent, the film temperatures. These and similar data for bearings subjected to a twisting couple are presented in three-dimensional plaster models as well as in curves.

Charles D. Strang, Jr., USA

1257. **Boyd, J., and Raimondi, A. A., Applying bearing theory to the analysis and design of journal bearings. I, II,** *J. appl. Mech.* 18, 3, 298–316, Sept. 1951.

Formulas given by Kingsbury (for infinite-length bearings) and Needs (for finite-length bearings) are presented in graphical form. This enables convenient and rapid calculation of friction coefficient, power loss, location of pressure extremes, lubricant flow rate, and temperature rise for full or partial journal bearings. Part I is based on the usual assumptions of zero and leakage, continuous oil film, uniform viscosity, and ideal geometry. Part II provides corrections for end leakage based on Needs' results for a 120-degree bearing, which are assumed to hold for bearings of other ares. Sample calculations demonstrate use of charts helpful in predicting behavior of bearings of any particular configuration under known operating conditions. Results of charts and experiments agree moderately well. Eugene M. Simons, USA

1258. **Barwell, F. T., and Milne, A. A., Use of molybdenum disulphide in association with phosphated surfaces,** *Scient. Lubr.* 3, 9, 10–14, Sept. 1951.

Experiments were conducted to test the lubricating qualities of MoS_2 for slider bearing applications. On the basis of tests with flat steel rubbing surfaces in a reciprocating testing machine under loads up to 267 psi and speeds up to 1000 cpm, the following conclusions were reached: (1) A nonmetallic coating, such as a phosphated surface, is essential for proper protection of MoS_2 lubricated surfaces. (2) Lubrication is improved markedly if the MoS_2 is bonded to the surfaces rather than merely rubbed on. (3) Neither the phosphate coating alone nor the MoS_2 alone is adequate. (4) A phosphated/paraffin-waxed surface is almost as good as a phosphated/bonded MoS_2 surface, but the former is not suitable for use at elevated temperatures.

This type of lubrication would be applicable where temperatures are high or where dry surfaces are required, so that normal methods of lubrication are impracticable. Reviewer feels that tests at higher temperature are needed.

Eugene M. Simons, USA

1259. **Cameron, A., Hydrodynamic lubrication of rotating disks in pure sliding. A new type of oil film formation,** *J. Inst. Petrol.* 37, 332, 471–486, Aug. 1951.

Current lubrication theory predicts that a fluid film cannot exist between the peripheries of two disks which are loaded against each other and which have surface speeds of equal magnitude but opposite direction, resulting in pure sliding. Author postulates that solution of the Reynolds equation with variable viscosity term might result in a final load equation which would predict some load capacity for the pure sliding case. Differential equations including effects of viscosity variation along and across the film, surface temperatures due to frictional heating, elastic deformation of the surfaces, and adiabatic heating of the oil are set up in the appendix. A simplified analysis is made, based on two large assumptions, and predicts the existence of a fluid film. Simple experiments are conducted with rotating disks, and a fair correlation with analytical results is obtained.

Charles D. Strang, Jr., USA

Marine Engineering Problems

1260. **Leide, N. G., and Ek, B., Forces and friction on launching of larger tank vessels** (in Swedish), *Tekn. Tidskr.* 81, 42, 975–980, Nov. 1951.

For three 24,000-ton vessels, by means of strain gages, authors have measured the forces on the launching triggers during the period from settling the wedges to removing the last bilge blocks and releasing the triggers. The forces were found greater than expected from handbook data but in good agreement with figures relating to the special grease employed. For one of the launches, the way-time function was electrically registered and speed-time as well as acceleration-time graphs drawn by graphical derivation finally converted to speed-way and force-way diagrams. The latter gives initial accelerating force considerably less than force on triggers. As explanation, authors propose that friction before release is not fully developed.

Reviewer feels it would be interesting to know whether the cooperation of triggers and launching ways indicated such a condition. It should be observed that the double derivations give considerable uncertainty. E. Hogner, Sweden

1261. **Gawn, R. W. L., Results to date of comparative cavitation tests of propellers,** *Trans. Soc. nav. Arch. mar. Engrs.*, 31 pp., 1951.

Three propeller series are being tested in eight tunnels. Three-bladed propellers of ogive sections have diameters from 8 to 18 in., and the five tunnels used to date have throat areas between 2.2 and 6.0 sq ft.

Thrust and torque coefficients and efficiency are presented vs. advance coefficient for 12 and 9-in. Series 1 propellers in four tunnels for several cavitation indexes and speeds, and for 12 and 8-in. Series 2 propellers in four tunnels. Some disagreement noted is attributed to equipment. Thrust and torque breakdown occur at approximately the same advance coefficient for a given cavitation number in each tunnel. No consistent trends are noted with water speed or Reynolds number.

J. M. Robertson, USA

1262. **Brard, R., Investigations of pitching,** *David W. Taylor Mod. Basin Transl.* 232, 24 pp., Sept. 1951.

Translation from paper presented at the convention of L'Association Technique Maritime et Aéronautique, June 1945.

1263. **Tulin, M. P., The separation of viscous drag and wave drag by means of the wake survey,** *David W. Taylor Mod. Basin Rep.* 772, 6 pp., July 1951.

The wake-survey method of measuring viscous drag indicates the theoretical possibility of separation of the viscous and wave

drags. The method is, in a general way, identical for submerged and surface flows. For submerged flows, resistance may be due to unsteady effects, viscous effects, "induced flow," and, in the case of gas, "supersonic wave" effects. Surface flows cause additional resistance effects.

According to A. Betz [in "A method for the direct determination of wing-section drag," 1925], the method of pressure surveys normal to the flow and directly behind the body in the narrow wake region was later developed into a standard technique of the aeronautical researcher. This wake-survey method, although developed in principle by Froude, has apparently not become a standard naval-architecture research method.

In this brief mathematical report, the result is shown that separation of wave and viscous drag is possible for surface flows as well as for submerged flows. It is assumed that only at a considerable distance downstream of the body do the surface phenomena involve significant rotational flow. The flow around the model is everywhere irrotational, except in the frictional wake. The entire flow field is considered the sum of a potential flow field and a rotational flow field. The model is imagined as contained in a "momentum-control surface," boxlike, of infinite dimensions excepting for the top and rear surfaces, which are close to the model. The force on the model, opposing "travel," is the sum of the net force on the control surface and the net momentum transfer through the control surface. Bernoulli's theorem applies where there is no vorticity. Integrating, there results an expression for the drag as the sum of viscous and wave components. The momentum transfer is due only to potential surface effects.

The utility of the method will depend on solution of practical problems of application. Drag-prediction techniques could be improved through replacement of the Froude method, in which the viscous drag is not measured but is estimated.

Eastman Smith, USA

1264. Walker, W. P., Detection of laminar flow on ship models, *Shipbuilder* **57,** 498, 267–270, Apr. 1950.

Hydroquinone diacetate dissolved in acetone is sprayed on a black enamel base giving a whitish film which dissolves rapidly when exposed to turbulent water flow. Turbulence inducers aid in defining laminar flow as their wakes produce no change in color when in turbulent flow. Laminar flow is found on about 15% of a 16-ft model, in agreement with results inferred from trip-wire studies.

J. M. Robertson, USA

1265. Hughes, G., and Allan, J. F., Turbulence stimulation on ship models, *Trans. Soc. nav. Arch. mar. Engrs.*, 23 pp., 1951.

In towing-tank tests of model ships, it is essential to stimulate completely turbulent flow (which occurs in full scale). Authors report British tests of (a) sand strips, (b) trip wires, (c) small pins, all located near the bow profile. Photographs of white ink filaments show degree of turbulence. Total drag resistance was measured for several models (15 to 20 ft) at typical speeds. Also estimates were made (theoretically and experimentally) of drag on wires and pins. Conclusions: Excess drag of wires or pins about the same, roughly $\frac{1}{2}$ % of total drag; both are about equally effective in stimulating turbulence under the stated conditions, seeming to be worth while and better than sand strips.

A. O. Williams, Jr., USA

1266. Nordström, H. F., Some tests with models of small vessels, *Medd. SkeppsProvAnst. Göteborg* no. 19, 41 pp., 1951.

This article will interest builders of small boats for whom relevant information for estimating speed and power is not available. The tests cover typical hull shapes for displacements of 10 to 30 tons and speeds of 10 to 15 knots. Results are presented for some 16 models, some of which were run at three displacements. Although the majority are of round bottom, many are flat in the stern, and two models are of chine construction.

F. E. Reed, USA

1267. Ingram, L. F., and Peile, L. A. B., Boiler and turbine testing, *Trans. Inst. mar. Engrs.* **63,** 9, 179–194, Sept. 1951.

Progress report on: (a) 650 psi and 850 F superheat "Daring" boiler; (b) H. P. and L. P. reaction steam turbines fitted in the Daring Class destroyers. Author does not release any performance characteristics for security reasons. The paper is an exposé of certain teething troubles during testing. The only test data that author discloses are the variation of temperatures in the turbine and the changes of casing clearances for various loads during maneuvering trials.

Paper gives short descriptions of the British Admiralty-sponsored organizations for testing of power units and their auxiliaries.

S. Eskinazi, USA

1268. de Dinechin, G., Note on the time for submarines to rise to the surface by blowing ballast (in French), *Bull. Assn. tech. marit. aéro.* no. 49, 97–116, 1950.

Only the case where submarine rises at zero trim is treated. Approximate and numerical solutions of equation of motion, which contains a drag term proportional to square of speed and buoyancy term, are given. It is not clear, either from definition of displacement or from examples, whether effect of virtual mass has been considered. Since virtual mass nearly doubles inertia effect, its omission would be serious. Computed depth-time curves are compared with results of tests on two submarines of very different types. Since drag coefficient in equation is derived from same experimental curve, predicted and measured curves are not entirely independent. A remarkable result is that one submarine has more than four times the drag of the other. Reviewer believes this to be due to laminar separation in one case and turbulent in the other, as appears to be indicated by the estimated range of Reynolds numbers.

It is found that rising time varies approximately as 3/2 power of depth, as square root of drag, and inversely as square root of quantity of ballast-blowing air. Author states, however, that rate of rise is greatly increased by propelling submarine at positive trims.

Louis Landweber, USA